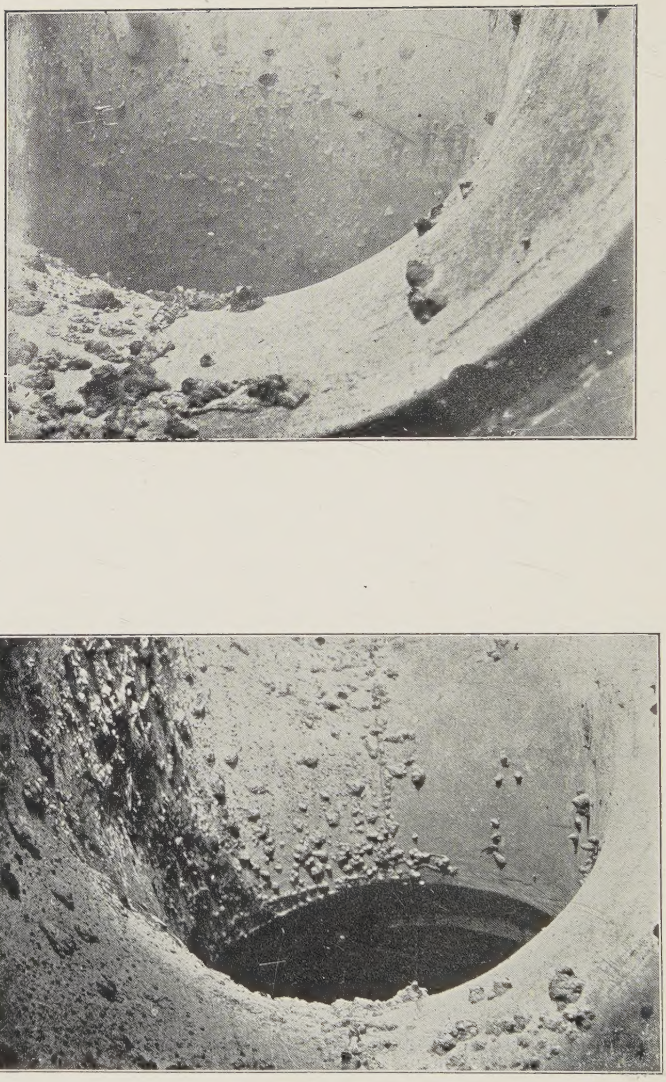
# HYDRAULIC TABLES



Tubercles Growing in Iron Water-pipes.

# HYDRAULIC TABLES

THE ELEMENTS OF GAGINGS AND THE FRICTION OF WATER FLOWING IN PIPES AQUEDUCTS, SEWERS, ETC.

*AS DETERMINED BY THE HAZEN AND WILLIAMS FORMULA*

AND THE

FLOW OF WATER OVER SHARP-EDGED AND IRREGULAR WEIRS, AND THE QUANTITY DISCHARGED

*AS DETERMINED BY BAZIN'S FORMULA AND EXPERIMENTAL INVESTIGATIONS UPON LARGE MODELS*

BY

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## PREFACE TO THE SECOND EDITION

In preparing the Second Edition for the press such errors as have appeared in the original text and tables have been corrected, and while it is not to be hoped that all have yet been eliminated the continuous use of the book for over three years has failed to develop others. Beyond an explanation of the derivation of the last term in the Hazen and Williams formula, the changes are confined to that part of the book devoted to the flow of water over weirs, where some new matter relating to submerged weirs is presented in the text, and where the table of discharge by Bazin's formula has been extended to cover variations of head by 0.01 of a foot from zero to 6 feet, making in all a table of thirty pages instead of the two pages in the former edition. A table of discharge of high weirs 10, 20, and 30 feet, under heads from 6 to 20 feet has been added and a new title page has been written, giving a more correct description of the scope of the book, and the table of contents has been extended. These additions have all been made in response to requests or suggestions from users of the former edition, and it is believed they will appreciably increase the usefulness of the volume.

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## PREFACE TO THE THIRD EDITION

In the Third Edition a new chapter, "Additional Data," is added as a brief statement of how the procedure used by the authors fits with the numerous additional data now available. A plotting showing graphically the most important new and old data, and the relations between them, and the procedure used, has also been added.

May 11, 1920.

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## NOTE TO 1933 PRINTING OF THIRD EDITION

Two new tables have been added, giving the flow in pipes 14 and 18 inches in diameter. It is believed that engineers will find these new data particularly useful. The calculations were made by Fuller and Everett.

# CONTENTS.

# INTRODUCTION.

The following tables show the flow of water in pipes and other passages, as computed by the Hazen-Williams hydraulic slide-rule, based upon the formula

$$v = cr^{0.63}s^{0.54}0.001^{-0.04}.$$

The most commonly used formula for determining the velocity of flow of water in pipes and channels is the Chezy formula, namely

$$v = c\sqrt{sr},$$

where $v$ is the velocity in feet per second, $s$ is the hydraulic slope, and $r$ the hydraulic radius in feet. $c$ is a factor the value of which is an approximation to a constant, but depends upon the roughness of the pipe and upon the hydraulic radius and slope. The variations in the value of $c$ are considerable, and make the general use of the formula difficult.

Kutter's formula was devised to compute the value of $c$ in the Chezy formula. The value of $c$ so computed depends upon an assumed coefficient of roughness, upon the slope, and upon the hydraulic radius. With the same degree of roughness the value of $c$ increases with the hydraulic slope and with the hydraulic radius. This is because the exponents used for these terms in the formula are below the true values. If the exponents were increased to correspond more nearly with the facts, the variations in the value of $c$ would become less. If exponents could be selected agreeing perfectly with the facts, the value of $c$ would depend upon the roughness only, and for any given degree of roughness $c$ would then be a constant. It is not possible to reach this actually, because the values of the exponents vary with different surfaces, and also their values may not be exactly the same for large diameters and for small ones, nor for steep slopes and for flat ones. Exponents can be selected, however, representing approximately average conditions, so that the value of $c$ for a given condition of surface will vary so little as to be practically constant. Several such "exponential" formulas have been suggested. These formulas are among the most satisfactory yet devised, but their use has been limited by the difficulty in making computations by them. This difficulty was eliminated by the use of a slide-rule constructed for that purpose.

The exponents in the formula used were selected as representing as nearly as possible average conditions, as deduced from the best available records of experiments upon the flow of water in such pipes and channels as most frequently occur in water-works practice. The last term, $0.001^{-0.04}$, is a constant, and is introduced simply to equalize the

value of $c$ with the value in the Chezy formula, and other exponential formulas which may be used at a slope of 0.001 instead of at a slope of 1.*

The slide-rules were furnished by the Abbott-McKay Corporation, 21 Pearl St., Boston, Mass., the work being done in Germany. Suitable scales were laid out and the position of each graduation was computed to 0.01 millimeter. The drawings were then engraved upon steel and reproduced upon slide-rules of the general size and appearance of the ordinary 10-inch Mannheim rule. The graduation is very perfectly done, and the accuracy obtained is practically that which can be secured with the ordinary slide-rule of this size.

All the computations of figures contained in this volume, except a few fundamental ratios, have been made with the slide-rule, and only such accuracy has been sought as can readily be obtained by this method of computation.

This formula has been used by the authors for some time, and it is hoped that the tables will be useful to those not accustomed to the use of the slide-rule, and also to those who use the slide-rule, as a reference showing velocities and velocity heads, and establishing beyond question the position of the decimal point, which is the most troublesome feature in the use of the slide-rule to beginners.

These tables are not confined to a single value of the coefficient of roughness, which is called $c$. Instead, a series of values of $c$ is given in the various columns, and under each are placed the corresponding losses of head. The headings also indicate in a general way the class of pipe for which the particular coefficient should be used, but these indications are only general, and it is the intention to leave the matter so that users can select such values of $c$ as in their judgment represent the particular conditions upon which they are figuring.

The gradual roughening of the interior of cast-iron pipe is one of the most familiar of water-works phenomena. It is also one of the most difficult to compute. In a general way it may be said that in a series of years, which is not long compared with the total life of the pipe, the roughening of the surface and the reduction of the area through rusting and tuberculation reach such an extent that twice as much head is consumed in sending a given volume of water through it as was the case when the pipe was new.

In a particular set of foreign tables, based on the Darcy formula,

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* Because engineers generally know the value of $c$ in the Chezy formula for ordinary slopes (about 1 in 1000) it was decided to frame the Hazen and Williams formula so as to have these old and already known coefficients applicable.

The Chezy formula is $v=cr^{0.5}s^{0.5}$.

The Hazen and Williams formula was $v=c'r^{0.63}s^{0.54}$.

For $r=1$ and $s=1$, $c=c'$.

To make $c'=c$ for $r=1$ and $s=0.001$ we have $(0.001)^{0.5}=b(0.001)^{0.54}$, whence $b=0.001^{-0.04}$ and the Hazen and Williams formula becomes

$$v=cr^{0.63}s^{0.54}0.001^{-0.04}.$$

the loss of head is given for new pipe, and in the second column, designated old pipe, a figure twice as large is given. This has certain advantages over a table of factors to be applied to pipes of different ages, as has been done in several American publications, because it is less apt to be forgotten; and while it is a crude precedure, it keeps in mind the fact that old pipe will pass very much less water than new pipe.

In this volume effort has been made to put this subject in better shape. It is a difficult matter to handle adequately, for no two pieces of iron pipe deteriorate at the same rate, and any figures given are therefore at best only approximations to averages, which averages may be very far from individual cases.

The system used is to put certain figures surrounded by circles over the columns. This mark was adopted because no words could be found sufficiently concise and at the same time accurate. Over the column for $c=140$ are placed two zeros in a circle: 00. That indicates that this coefficient is obtained with the very best cast-iron pipe, laid perfectly straight, and when new. Over $c=130$ is placed one zero in a circle, 0, and this is the value that can be fairly counted on for good new cast-iron pipe. Over the following columns are placed figures in circles. These figures show the age in years at which, on an average, as nearly as we know, cast-iron pipe will reach the values given in the column underneath. It must be understood that these are necessarily very rough approximations, based on the best data available, which are principally for soft and clear but unfiltered river-waters. Hard waters and lake waters will often attack the pipe less rapidly, and the figures must then be increased. Sometimes they must be multiplied by two or more. Other waters will corrode the pipes more rapidly than the average, and for them the values will be reached more quickly than the figures indicate.

The divergence with different castings and with different kinds of water is greatest in the smallest pipes, and no attempt is made to extend the figures in the circles to the sizes below four inches in diameter.

Steel pipes tuberculate and corrode in much the same manner as cast-iron pipes. On account of the rivets and in-and-out joints the average value of $c$ is lower than for cast-iron pipe. The data at hand indicate a value of 110 for new pipe, decreasing in the course of about ten years to 100. For older pipes, as far as the present data go, steel pipe of a given age will carry the same quantity of water as cast-iron pipe of the same size and ten years older.

*On the Value of c.*—In the *Engineering Record* of March 28, 1903, was published by the authors a table of the values of $c$ computed from published experiments upon the friction of water in pipes and conduits of various kinds, the results being selected as the most reliable available data. This table, with some additions, is as follows:

## TABLE NO. 1.—PIPE VALUES.

| Experimenter. | Diameter in Inches. | Number of Observations. | Range of Velocity, Feet per Second. | Range of $c$ in H. & W. Formula. | Mean Value of $c$. | Remarks. |
|---|---|---|---|---|---|---|
| | | | NEW CAST-IRON PIPE. | | | |
| Darcy | 3.22 | 8 | 0.36 to 5.15 | 119.5 to 120.0 | 120 | Uncoated |
| " | 5.39 | 8 | 0.5 " 7.48 | 132.1 " 125.8 | 129 | " |
| " | 7.40 | 6 | 1.6 " 8.22 | 125.0 " 116.0 | 121 | " |
| Williams, Hubbell, Fenkell | 12 | 30 | 1.0 " 5.00 | 139.3 " 148.5 | 144 | Coated, very straight, no specials |
| Iben | 12 | 4 | 1.6 " 3.1 | 107.0 " 121.5 | 114 | Coated, Bonn service main |
| " | 12 | 4 | 1.6 " 3.1 | 106.0 " 117.0 | 111 | " " " " |
| Williams, Hubbell, Fenkell | 16.02 | 20 | 1.0 " 5.0 | 146.0 " 145.8 | 146 | " well laid |
| " " " | 16.02 | 30 | 1.0 " 5.0 | 145.0 " 145.6 | 145 | " " " |
| Lampe | 16.48 | 4 | 1.6 " 3.1 | 129.0 " 133.0 | 131 | " Danzig main |
| Darcy | 19.68 | 9 | 1.4 " 3.7 | 112.0 " 117.8 | 115 | Uncoated |
| Williams, Hubbell, Fenkell | 29.96 | 30 | 1.25 " 2.90 | 138 " 142 | 140 | Coated, straight, no specials |
| Kuichling | 36 | 2 | 4.2 | 129 | ...... | " Rochester main |
| Stearns | 48 | 3 | 2.6 to 6.2 | 142.0 to 141.0 | 142 | " Rosemary siphon |
| Gale | 48 | 1 | 3.5 | 112.3 | ...... | " Edinburgh main |
| Fenkell | 60 | 5 | 0.73 to 1.10 | 105.0 to 110.0 | 107 | " Erie Intake 8 years old |
| | | | CLEANED CAST-IRON PIPE. | | | |
| Darcy | 1.43 | 7 | 0.4 to 3.7 | 130 to 134 | 132 | Paris main |
| " | 3.16 | 7 | 0.6 " 5.0 | 124 " 114 | 119 | " " |
| Brackett | 6 | 6 | 0.95 " 2.46 | 100 " 86 | 93 | Boston main |
| Darcy | 9.63 | 7 | 0.9 " 8.44 | 110 " 103 | 107 | Paris main |
| " | 11.69 | 8 | 0.8 " 10.4 | 107 " 106 | 107 | " " |
| FitzGerald | 48 | 21 | 2.0 " 5.0 | 144 " 141 | 142 | Rosemary siphon |

| | | | | | | |
|---|---|---|---|---|---|---|
| **TUBERCULATED CAST-IRON PIPE.** | | | | | | |
| Darcy | 1.41 | 6 | 0.26 to 2.1 | 86 to 76 | 81 | Paris main |
| " | 3.13 | 6 | 0.4 " 3.7 | 82 " 85 | 83 | " " |
| Brackett | 4 | 4 | 0.47 " 1.23 | 13 " 20 | 16 | Boston main |
| " | 4 | 3 | 0.51 " 1.19 | 15 " 22 | 18 | " " |
| " | 6 | 7 | 0.38 " 1.70 | 38 " 30 | 34 | " " |
| " | 6 | 8 | 0.38 " 1.70 | 44 " 42 | 43 | " " |
| Darcy | 9.57 | 8 | 1.0 " 1.26 | 89 " 79 | 84 | Paris main |
| Forbes | 16 | 4 | 1.15 " 1.97 | 111 " 102 | 106 | Brookline force main |
| Kuichling | 36 | 2 | 4.08 | 81 | ...... | Rochester main |
| FitzGerald | 48 | 35 | 1.0 to 5.0 | 119 to 105 | 112 | Rosemary siphon |
| **RIVETED PIPE.** | | | | | | |
| Darcy | 1.05 | 7 | .30 to 2.79 | 131 to 125 | 128 | Coated sheet iron |
| Giltner and Ketchum | 3.00 | 222 | .18 " 2.33 | 118 " 116 | 119 | Galvanized sheet iron |
| Darcy | 3.25 | 7 | .58 " 6.14 | 124 " 143 | 133 | Coated sheet iron |
| " | 7.72 | 10 | .59 " 10.01 | 141 " 144 | 142 | " " " |
| H. Smith, Jr. | 10.93 | 5 | 4.70 " 10.00 | 119 " 124 | 121 | Riveted sheet iron |
| Darcy | 11.22 | 7 | 1.30 " 10.52 | 123 " 136 | 129 | Coated sheet iron |
| H. Smith, Jr. | 12.67 | 4 | 4.60 " 10.10 | 121 " 118 | 119 | Riveted sheet iron |
| " " " | 14.76 | 6 | 4.40 " 12.10 | 132 " 123 | 127 | " " " |
| Herschel | 36.00 | 8 | 0.56 " 5.70 | 122 " 98 | 110 | Riveted steel |
| Kuichling | 38.00 | 10 | 3.71 " 3.91 | 107 " 110 | 108 | Riveted sheet steel |
| Herschel | 42.00 | 24 | 0.96 " 4.99 | 130 " 88 | 109 | Riveted steel |
| " | 47.4 | 51 | 2.04 " 6.06 | 126 " 91 | 104 | " " |
| Marx, Wing and Hoskins | 72.24 | 29 | 1.57 " 3.80 | 117 " 108 | 111 | Riveted sheet steel |
| " " " " | 72.24 | 39 | 1.12 " 4.80 | 87 " 100 | 97 | " " " |
| Herschel | 102.96 | 40 | 1.00 " 4.50 | 127 " 101 | 114 | " " iron |
| **WOODEN-STAVE PIPE.** | | | | | | |
| Adams | 14.05 | 5 | .70 to 1.53 | 124 to 134 | 129 | Los Angeles |
| Noble | 44 | 11 | 3.46 " 4.80 | 112 " 115 | 113 | Seattle |
| " | 54 | 11 | 2.28 " 4.70 | 119 " 127 | 123 | " |
| Marx, Wing and Hoskins | 72.36 | 48 | 1.20 " 5.30 | 124 " 117 | 120 | Ogden |

## PIPE VALUES—(*Continued*).

| Experimenter. | Diameter in Inches. | Number of Observations. | Range of Velocity, Feet per Second. | Range of $c$ in H. & W. Formula. | Mean Value of $c$. | Remarks. |
|---|---|---|---|---|---|---|
| | | | RECTANGULAR UNPLANED WOODEN PIPES. | | | |
| Darcy and Bazin | 2.625′×1.64′ $r=.505$ | 8 | 1.67 to 6.37 | 122.0 to 112.0 | 115 | Long dimension horizontal |
| " " " | 1.575′×.984′ $r=.303$ | 8 | 1.23 " 5.31 | 116.8 " 106.8 | 114 | " " " |
| | | | CEMENT PIPE. | | | |
| Fanning | 20 | 11 | 1.49 to 4.04 | 127 to 118 | 122 | Cement-lined iron |
| Bazin | 31.50 | 10 | 2.78 " 6.60 | 148 " 144 | 146 | Experimental conduit |
| | | | CIRCULAR BRICK TUNNELS. | | | |
| Clarke | 90 | 2 | 3.769 to 3.798 | 113 to 111 | 112 | Boston main drainage sewer |
| Benzenberg | 144 | 10 | 3.90 " 7.00 | 95 " 80 | 87 | Milwaukee sewer |
| | | | NEW WROUGHT-IRON PIPE. | | | |
| H. Smith, Jr. | 0.628 | 2 | 1.03 to 1.58 | 100 to 127 | 113 | $\frac{1}{2}$-inch gas-pipe |
| " " " | 1.054 | 8 | 0.96 " 3.17 | 114 " 134 | 124 | 1- " " |
| | | | NEW GALVANIZED WROUGHT-IRON PIPE. | | | |
| Saph and Schoder | 1.042 | 7 | 2.80 to 10.04 | 99.0 to 108.0 | 105 | No fittings. Standard 1″ pipe |
| " " " | 0.850 | 14 | 2.62 " 11.47 | 121.0 " 128.0 | 126 | " " " $\frac{3}{4}$″ " |
| " " " | 0.626 | 7 | 2.46 " 12.78 | 117.5 " 121.0 | 119 | " " " $\frac{1}{2}$″ " |
| " " " | 0.486 | 8 | 1.67 " 10.88 | 111.0 " 116.0 | 114 | " " " $\frac{3}{8}$″ " |
| " " " | 0.350 | 9 | 1.86 " 10.76 | 88.0 " 98.5 | 92 | " " " $\frac{1}{4}$″ " |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | New Brass Pipe. | | | |
| Saph and Schoder.......... | 0.50 | 39 | 0.95 to 14.97 | 129 to 146 | 131 | Seamless drawn |
| " " " .......... | 0.63 | 20 | 0.65 " 6.76 | 142 " 149 | 145 | " " |
| " " " .......... | 0.82 | 16 | 0.72 " 5.47 | 130 " 146 | 138 | " " |
| " " " .......... | 1.05 | 10 | 0.36 " 3.09 | 131 " 145 | 138 | " " |
| " " " .......... | 1.24 | 16 | 0.43 " 3.64 | 130 " 144 | 137 | " " |
| " " " .......... | 1.50 | 16 | 0.38 " 4.36 | 130 " 147 | 138 | " " |
| " " " .......... | 2.09 | 9 | 0.63 " 4.95 | 140 " 150 | 145 | " " |
| | | | New Lead Pipe. | | | |
| Reynolds.................. | 0.498 | 6 | 1.14 to 2.14 | 136 to 138 | 137 | |
| Darcy..................... | 0.55 | 2 | 0.81 " 1.46 | 133 " 135 | 134 | |
| " ..................... | 1.06 | 5 | 0.62 " 3.35 | 122 " 139 | 130 | |
| " ..................... | 1.61 | 7 | 0.39 " 7.56 | 116 " 129 | 123 | |
| | | | Glass Pipe. | | | |
| H. Smith, Jr............... | 0.75 | 2 | 1.40 to 2.65 | 128 to 133 | 130 | |
| " " " ............... | 0.92 | 2 | 1.95 " 2.94 | 131 " 135 | 133 | |
| Darcy..................... | 1.95 | 5 | 0.50 " 6.92 | 119 " 125 | 122 | |
| | | | New Wood, Bored. | | | |
| H. Smith, Jr............... | 1.26 | 2 | 1.65 to 2.47 | 95 to 95 | 95 | |
| | | | Fire-hose. | | | |
| Freeman................... | 2.65 | 4 | 12.50 to 20.00 | 144 to 141 | 143 | "A," extremely smooth |
| " .................. | 2.47 | 3 | 13.40 " 20.00 | 140 | 140 | "C," rubber-lined |
| " .................. | 2.49 | 4 | 13.20 " 21.00 | 139 to 136 | 138 | "D," " |
| " .................. | 2.68 | 4 | 7.50 " 17.00 | 136 " 130 | 132 | "E," " |
| " .................. | 2.69 | 4 | 11.50 " 18.00 | 114 " 119 | 116 | "I," " |
| " .................. | 2.12 | 3 | 14.00 " 21.81 | 134 " 135 | 135 | "M," " |
| " .................. | 2.53 | 8 | 3.50 " 19.00 | 122 " 101 | 106 | "K," "mill hose" |
| " .................. | 2.60 | 7 | 3.50 " 20.00 | 93 " 87 | 89 | "L," unlined linen hose |

In a general way it may be said that for cast-iron pipe, very straight and smooth, $c$ may be as high as 140, but for ordinary conditions 130 is a fair value for new pipe. As pipes rust and become dirty, the value of $c$ decreases, as has been mentioned above. For new riveted steel pipe $c$ is about 110.

In making estimates for pipe-lines where the carrying capacity after a series of years, rather than the value of the new pipe, is the controlling factor, a considerably lower value of $c$ must be used, depending upon the amount of deterioration which is contemplated. A fair value for general computation is $c=100$ for cast-iron pipe and $c=95$ for steel pipe, but for small iron pipes a somewhat lower value of $c$ should be taken. In the pipe tables the column of slopes for $c=100$ is printed in heavier-faced type than the rest, as these values are the ones which will probably be most often required. Lead, brass, tin, and glass, and other pipe presenting perfectly smooth surfaces, and perfectly straight, will give values of $c$ up to 140. A very little falling off in the smoothness will reduce the value of $c$ to 130 and 120, or even less. For smooth wooden pipe or wooden-stave pipe 120 seems a fair value. For masonry conduits of concrete or plastered, with very smooth surfaces, when clean, values of $c=140$ may be observed. Generally such surfaces become slime-covered, reducing the value of $c$ to 130 or less in a moderate length of time; and if the surfaces are only a little less smooth, say in such shape as is represented by ordinary good work, the value of $c$ is reduced to 120. A conservative value for general use with first-class masonry structures is about 120. For brick sewers much lower values may be used, and $c=100$ seems safe. For vitrified pipe $c=110$ may be used. It must be understood that these values depend entirely upon the smoothness and regularity of the surfaces, and are likely to vary in individual cases.

This formula was designed primarily for computing the flow of water in pipes. It seems reasonably well adapted for computing the flow in open channels, and the slide-rules have been made so as to allow this application. A table has been prepared to show the application of this formula to the most reliable experiments upon open channels. From the data therein presented the investigator may determine for himself the probable accuracy to be obtained and the value of $c$ which should be used in a given case.

# TABLE NO. 2.—OPEN-CHANNEL VALUES.

| Experimenter. | Number of Observations. | Width at Surface, Feet. | Mean Depth at Deepest Part of Section, Feet. | Slope, Feet per 1000 Feet. | Range of $r$ in Feet. | Range of $v$, Feet per Second. | Range of $c$ in H. & W. Formula. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | | | RECTANGULAR CONDUITS. | | | | |
| Darcy and Bazin, S. II | 12 | 5.94 | .18 to .91 | 4.9 | .168 to .696 | 3.34 to 8.07 | 135 to 140 | Surface of pure cement |
| " " " S. III | 12 | 6.27 | .20 " 1.04 | 4.9 | .192 " .779 | 2.75 " 6.72 | 104 " 110 | " " brick laid flat |
| " " " S. IV | 11 | 6.01 | .41 " 1.30 | 4.9 | .357 " .910 | 2.95 " 5.57 | 76 " 78 | " " gravel $\frac{3}{8}''$ to $\frac{7}{8}''$ diam. |
| " " " S. V | 12 | 6.11 | .32 " 1.46 | 4.9 | .291 " .987 | 1.79 " 4.90 | 52 " 66 | " " " $1\frac{1}{8}''$ to $1\frac{3}{8}''$ " |
| " " " S. VI | 12 | 6.53 | .26 " 1.28 | 2.08 | .240 " .922 | 2.08 " 5.21 | 109 " 118 | " " unplaned plank |
| " " " S. VII | 12 | 6.53 | .20 " .94 | 4.9 | .188 " .727 | 2.71 " 7.15 | 112 " 118 | " " " " |
| " " " S. VIII | 12 | 6.53 | .15 " .78 | 8.24 | .147 " .630 | 3.52 " 8.57 | 113 " 118 | " " " " |
| " " " S. IX | 7 | 6.51 | .30 " 1.44 | 1.5 | .276 " .998 | 1.80 " 4.66 | 103 " 118 | " " " " |
| " " " S. X | 7 | 6.52 | .18 " .87 | 5.9 | .172 " .680 | 2.99 " 7.71 | 110 " 118 | " " " " |
| " " " S. XI | 7 | 6.50 | .15 " .77 | 8.39 | .146 " .621 | 3.54 " 8.74 | 117 " 119 | " " " " |
| " " " S. XII | 7 | 6.43 | .33 " —* | 1.5 | .302 " 1.076 | 1.65 " 4.19 | 89 " 101 | Surface covered with laths $\frac{3}{8}''$ deep × 1.1″ wide, nailed $\frac{3}{8}''$ apart around sides and bottom transversely to current |
| " " " S. XIII | 7 | 6.43 | .22 " 1.05 | 5.9 | .205 " .790 | 2.50 " 6.48 | 83 " 92 | |
| " " " S. XIV | 7 | 6.40 | .19 " .94 | 8.86 | .182 " .726 | 2.85 " 7.26 | 82 " 87 | |
| " " " S. XV | 7 | 6.43 | .43 " 2.18 | 1.5 | .378 " 1.299 | 1.28 " 3.11 | 60 " 67 | Surface covered with lath as above but set 2″ apart |
| " " " S. XVI | 7 | 6.44 | .29 " 1.38 | 5.9 | .264 " .965 | 1.91 " 4.91 | 54 " 61 | |
| " " " S. XVII | 7 | 6.40 | .25 " 1.22 | 8.86 | .232 " .885 | 2.21 " 5.57 | 54 " 58 | |
| " " " S. XVIII | 12 | 3.93 | .27 " 1.46 | 4.9 | .235 " .839 | 3.37 " 7.59 | 112 " 114 | Surface of unplaned plank |
| " " " S. XIX | 11 | 2.625 | .26 " 1.50 | 4.3 | .214 " .700 | 2.85 " 6.48 | 106 " 117 | " " " " |
| " " " S. XX | 9 | 1.575 | .34 " .95 | 6.0 | .237 " .431 | 3.57 " 5.49 | 106 " 111 | " " " " |

* Conditions of flow irregular.

## OPEN-CHANNEL VALUES—(*Continued*).

| Experimenter. | Number of Observations | Width at Surface, Feet. | Mean Depth at Deepest Part of Section, Feet. | Slope, Feet per 1000 Feet. | Range of $r$ in Feet. | Range of $v$, Feet per Second. | Range of $c$ in H. & W. Formula. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| **TRAPEZOIDAL AND TRIANGULAR PLANK CONDUITS, UNPLANED.** | | | | | | | | |
| Darcy and Bazin, S. XXI | 12 | 6.56 | .40 to 1.77 | 1.5 | .334 to 1.097 | 2.39 to 4.87 | 120 to 117 | Sides at 45° for 1.64′, then vertical above; bottom 3.28′ wide |
| " " " S. XXII | 12 | variable | .30 " 1.44 | 4.9 | .257 " .837 | 3.58 " 7.93 | 113 " 120 | One side vertical, other at 45°; bottom 3.1′ wide |
| " " " S. XXIII | 12 | " | .92 " 2.37 | 4.9 | .327 " .839 | 4.13 " 7.75 | 114 " 118 | Both sides at 45°, vertex down. |
| **SEMICIRCULAR CONDUITS.** | | | | | | | | |
| " " " S. XXIV | 12 | variable | .59 to 2.08 | 1.5 | .366 to 1.034 | 3.02 to 6.11 | 145 to 152 | Radius 2.05′, surface pure cement |
| " " " S. XXV | 12 | " | .61 " 2.09 | 1.5 | .379 " 1.038 | 2.87 " 5.66 | 132 " 141 | Radius 2.05′, surface cement mixed with ⅓ of fine sand |
| " " " S. XXVI | 13 | " | .63 " 2.29 | 1.5 | .390 " 1.148 | 2.61 " 5.54 | 121 " 129 | Radius 2.295′, partly planed plank |
| " " " S. XXVII | 10 | " | variable | 1.5 | .454 " 1.012 | 2.17 " 3.95 | 90 " 99 | Radius 2.00′, surface of small gravel ⅜″ to ⅞″ diameter set in cement |
| **SMALL RECTANGULAR CONDUIT.** | | | | | | | | |
| " " " S. XXVIII | 7 | 0.328 | .036 to .215 | 4.7 | .029 to .093 | .90 to 2.16 | 115 to 132 | Very smooth wood |
| " " " S. XXIX | 5 | 0.328 | .037 " .134 | 15.2 | .030 " .074 | 1.87 " 3.56 | 124 " 133 | " " " |
| " " " S. XXX | 6 | 0.312 | .048 " .269 | 8.1 | .038 " .102 | .72 " 1.88 | 57 " 82 | Surface covered with cloth, lower corners rounded |
| " " " S. XXXI | 9 | 0.312 | .036 " .226 | 15.2 | .031 " .095 | .69 " 2.23 | 45 " 71 | |

## OPEN-CHANNEL VALUES—(*Continued*).

| Experimenter. | No. of Observations. | Mean Depth, Feet. | Slope, Feet per 1000 Ft. | Range of $r$ in Feet. | Range of $v$, Feet per Second. | Range of $c$ in H. & W. Formula. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | AQUEDUCTS. | | | | |
| Fteley and Stearns | 9 | 1.518 to 4.552 | .1928 to .1922 | 1.078 to 2.333 | 1.827 to 2.926 | 135 to 132 | Sudbury. Hard brick, fairly clean and smooth. Slope of bottom, 0.189. Horseshoe section, 8.3′ wide at bottom. Rad. = 4.5′. Invert 0.7′ deep |
| " " " | 9 | 1.505 " 4.541 | .1893 " .1889 | 1.071 " 2.330 | 1.844 " 2.937 | 137 " 134 | |
| " " " | 8 | 2.065 " 4.574 | .0493 " .1860 | 1.400 " 2.338 | 1.432 " 2.909 | 141 " 134 | |
| " " " | 8 | 2.192 " 4.972 | .0334 " .1793 | 1.468 " 2.417 | 1.207 " 2.889 | 140 " 135 | |
| " " " | 7 | 2.002 " 4.390 | .1998 " .2600 | 1.366 " 2.294 | 2.161 " 3.386 | 134 " 131 | |
| " " " | 7 | 1.799 " 3.878 | .2102 " .4913 | 1.251 " 2.151 | 2.448 " 4.407 | 140 " 132 | |
| " " " | 13 | 0.719 " 1.415 | .014 " .1715 | 0.493 " 1.016 | 0.443 " 1.577 | 145 " 137 | Same conduit carefully cleaned. Slope of bottom 0.16′ |
| Fteley | 17 | ............ | 0.133 | 0.76 " 3.84 | 1.11 " 3.4 | 118 " 130 | New Croton, New York |
| " | ...... | 12.8 | 0.133 | 3.93 | 3.07 | 122 | Same conduit at point of maximum discharge |
| | | | BRICK SEWERS. | | | | |
| Horton | 5 | 1.02 to 2.89 | 0.500 | 0.688 to 1.539 | 1.99 to 3.44 | 116 to 121 | Charlestown sewer 10 months in use |
| " | 2 | 2.91 " 3.29 | 0.500 | 1.546 " 1.650 | 2.97 " 3.16 | 105 " 106 | Do. 26 months in use |
| " | 3 | 2.29 " 3.26 | 0.500 | 1.342 " 1.645 | 2.66 " 3.04 | 102 " 102 | Do. 4 years in use |
| " | 7 | 1.02 " 4.62 | 0.333 | 0.619 " 2.309 | 1.58 " 4.18 | 123 " 141 | East Boston sewer 10 months in use |
| " | 4 | 2.15 " 3.20 | 0.333 | 1.280 " 1.771 | 2.55 " 3.18 | 123 " 127 | Do. 26 months in use |
| " | 4 | 1.99 " 4.18 | 0.333 | 1.120 " 2.130 | 2.38 " 3.30 | 117 " 127 | Do. 4 years in use |
| | | | CANALS AT MARSEILLES AND CRAPONNE. | | | | |
| Darcy and Bazin, Baumgarten } S. I | 1 | 2.5× 7.4* | 3.72 | 1.504 | 10.26 | 123 | Nearly rectangular; brick side and cement bottom |
| Ditto. | 1 | 3.0× 8.5* | .84 | 1.774 | 5.55 | 134 | Rectangular; smooth cut stone |
| Ditto. | 1 | 1.2× 3.5* | 29 | .708 | 11.23 | 74 | Nearly rectangular; hammered stone, rather rough |
| Ditto. | 1 | 0.9× 3.5* | 60 | .615 | 13.93 | 65 | |
| Ditto. | 1 | 1.6× 3.9* | 12.1 | .881 | 7.58 | 67 | |
| Ditto. | 1 | 1.5× 3.6* | 14 | .835 | 8.36 | 71 | |
| Ditto. | 1 | 4.5×19.7* | .43 | 2.871 | 2.54 | 65 | Mud, grass, and weeds; trapezoidal |

* Surface width.

## OPEN-CHANNEL VALUES—(*Continued*).

| Experimenter. | Number of Observations. | Area in Square Feet. | Slope, Feet per 1000 Feet. | Range of $r$ in Feet | Range of $v$, Feet per Second. | Range of $c$ in H. & W. Formula. | Remarks. |
|---|---|---|---|---|---|---|---|
| Cunningham (Ganges Canals, Roorkee Expts.) | 5 | ........... | .225 to .473 | 2.6 to 7.9 | 1.24 to 4.08 | 77 to 123 | Solani Canal, Left. Masonry in good condition |
| Ditto. | 4 | ........... | .190 " .240 | 5.0 " 8.0 | 2.7 " 4.1 | 83 " 86 | Solani Canal, Right. As last |
| Ditto. | 8 | ........... | .088 " .227 | 2.25 " 9.3 | 0.87 " 4.0 | 46 " 79 | Solani Canal, Main. Sides masonry, bottom clay and irregular |
| Ditto. | 2 | ........... | .208 " .191 | 8 " 9 | 3.1 " 3.2 | 61.6 to 61.8 | Betra. Similar to last |
| Ditto. | 2 | ........... | .140 " .160 | 6.3 " 7.5 | 2.6 " 2.9 | 74.4 " 69.2 | Jasli. Similar |
| Ditto. | 1 | ........... | .231 | 8.6 | 4.0 | 72 | 15 mile, old side. Earth beds very rough |
| Ditto. | 3 | ........... | .291 to .306 | 4.1 to 4.8 | 2.7 to 2.9 | 66.5 to 66 | Kamehera. Similar to last |
| | | | MASONRY SLUICEWAYS. | | | | |
| Darcy and Bazin, S. XXXII | 4 | 2.1 to 5.1 | 101.0 | .324 to .662 | 12.29 to 21.09 | 65 to 72 | Hammer-dressed, nearly rectangular. Bottom width 5.91′. Some adhering slime |
| " " " S. XXXIII | 4 | 2.9 " 7.0 | 37.0 | .424 " .852 | 9.04 " 15.08 | 70 " 75 | |
| " " " S. XXXIV | 5 | 8.9 " 27.5 | 14 6 | .856 " 1.694 | 4.19 " 8.99 | 34 " 48 | Flat trapezoid, hammer-dressed, covered with moss & mud. Bottom width 6.50′ |
| " " " S. XXXV | 5 | 6.6 " 21.6 | 14.2 | .703 " 1.491 | 5 66 " 11.26 | 53 " 66 | Same as last, but cleaned. Bottom width 5.87′ |

CANALS.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Darcy and Bazin, S. XXXIX | 4 | 2.0 to 4.9 | 8.1 | .406 to .766 | 5.73 to 8.75 | 104 to 110 | Smooth masonry. Nearly rectangular. Bottom width 3.9′ |
| " " " S. XL | 4 | 10.5 " 24.6 | .936 to .964 | 1.05 " 1.64 | 1.08 " 1.71 | 34 " 40 | Trapezoidal rough stone. Little vegetation. Bottom width 4.2′ |
| " " " S. XLII | 4 | 10.5 " 23.1 | .525 " .487 | 1.00 " 1.67 | 1.01 " 1.74 | 45 " 58 | Trapezoidal with earth bottom and masonry sides. Bottom width 7.1′ |
| " " " S. XLIV | 4 | 9.7 " 21.1 | .35 " .30 | 1.07 " 1.71 | 1.12 " 2.18 | 65 " 94 | Masonry in bad order. Vertical sides and circular invert. Bottom width 6.6′ |
| " " " S. XLV | 4 | 8.2 " 18.6 | .305 " .347 | .98 " 1.60 | 1.32 " 2.47 | 80 " 103 | Similar to last, but in better order. Bottom width 6.2′ |
| " " " S. XLVI | 4 | 7.4 " 16.6 | .648 " .683 | .88 " 1.50 | 1.47 " 2.78 | 64 " 84 | Similar. Bottom width 6.6′ |
| " " " S. XLVII | 4 | 11.8 " 26.8 | .464 " .493 | 1.09 " 1.71 | .82 " 1.68 | 37 " 55 | Earth, some vegetation. Form nearly arc of circle |
| " " " S. XLVIII | 4 | 10.1 " 25.9 | .555 " .515 | .99 " 1.71 | .96 " 1.75 | 42 " 56 | |
| " " " S. XLIX | 4 | 10.9 " 30.8 | .250 " .275 | .96 " 1.78 | .89 " 1.47 | 61 " 71 | Earth, no vegetation. Trapezoidal. Bottom width 6.5′ |
| " " " S. L | 4 | 11.3 " 32.0 | .310 " .330 | 1.05 " 1.85 | .82 " 1.41 | 47 " 60 | Similar to last. Bottom width 6.3′ |
| " " " S. XXXVI | 4 | 13.0 " 29.1 | .678 " .622 | 1.14 " 1.74 | .91 " 1.65 | 33 " 47 | Trapezoidal in earth with vegetation. Bottom width 3.7 |
| " " " S. XXXVII | 4 | 9.5 " 22.9 | .792 " .858 | .96 " 1.56 | 1.23 " 2.00 | 45 " 52 | Trapezoidal in stony earth. Little vegetation. Bottom width 3.9′ |
| " " " S. XXXVIII | 4 | 9.3 " 22.2 | .957 " .993 | .96 " 1.54 | 1.24 " 1.96 | 42 " 50 | Similar to last. Bottom width 4.1′ |
| " " " S. XLI | 4 | 11.3 " 27.2 | .445 " .455 | 1.04 " 1.71 | .96 " 1.51 | 46 " 56 | Similar to last. Bottom width 4.4′ |
| " " " S. XLIII | 4 | 11.6 " 28.7 | .420 " .470 | 1.06 " 1.76 | .89 " 1.39 | 43 " 47 | Similar to last with vegetation. Bottom width 4.3′ |
| Murray Blanchard, Chicago Drainage Canal 1914-7 | 92 | 3525 " 4240 | .001 " .045 | 17.02 " 19.58 | 1.58 " 2.74 | 77 " 97 | Rectangular section in smooth rock, width 160′-162′, depth 22′ to 26′. Flow diluted sewage |

No tables to show the application of these results, that is to say, tables corresponding to the pipe tables, have been made for open channels. The variations in the conditions of depth, width, slope and character of bottom and sides are so enormously great that solution of each particular problem by the use of the slide-rule is the only practical way of handling the subject.

The slide-rule will also be found more closely applicable to actual conditions in pipes than any tables, because it gives at once values for conditions falling between the values which it is practicable to show in the tables, and its use is therefore to be recommended in all cases where close computations are desirable.

# ADDITIONAL DATA.

It is eighteen years since the Williams-Hazen formula was first used and fifteen since the first edition of these tables appeared. During this time many new experiments on the flow of water in pipes have been made. As a new edition goes to press, it is appropriate to examine these to see if changes or adjustments are required.

There are three values open to consideration—two exponents and one coefficient. The exponents will be considered first.

## EXPONENT OF SLOPE.

This exponent shows the rate at which friction increases with velocity. A value for the exponent of $s$ may be obtained from a series of experiments made upon a single pipe line, but each series of experiments, to be useful, must cover a considerable range in velocities, and these velocities must extend at least as high as those ordinarily used in practice.

Experiments with seventeen pipes have been selected as being helpful in reaching a representative value for this exponent. Each of these pipes was very smooth. The value of the coefficient actually found in the experiments is taken as the best evidence of smoothness. Many older data have been excluded, because the values of $c$ show that the pipes which they represent were not really smooth. The best cast-iron pipe of fifty years ago was inferior in smoothness to average pipe of to-day.

Data for pipes less than two inches in diameter are not included. Such data are numerous and accurate; but viscosity is a greater element in the flow of water in small pipes. Viscosity tends to increase the exponent of $s$ in small pipes.

To get a good indication of the true exponent of $s$ for any pipe the range in velocities covered by the tests must be considerable. It was first intended to use only data where the tests extended to a velocity of ten feet per second; but a rigid application of this rule would leave so few data for large pipes, that the limit was reduced to five feet per second. Experiments in each series at low velocities if inconsistent with those obtained at higher velocities, have been omitted in computing the exponent, and for this reason there are divergences in a few cases from

## TABLE 1.—EXPONENT OF SLOPE.

| Number. | Diameter of Pipe (inches). | Kind of Pipe | Authority. | Approximate Date of Experiment. | Value of $c$ when $V=3.28$ | Range in Velocities. | Reciprocal of Exponent. | Reference. |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.06 | W. I. | Davis | 1908 | 144 | 1.5–14.7 | 1.85 | Am. Soc., 62; 97 |
| 2 | 2.09 | Brass | Saph and Schoder | 1903 | 143 | 1.0– 5.8 | 1.75 | Am. Soc., 51; 523 |
| 3 | 3.00 | W. I. | Schoder and Gehring | 1906 | 132 | 2.2–16.0 | 1.91 | E. Rec., 58; 241 |
| 4 | 3.25 | W. I. | Darcy | 1851 | 140 | 1.0–12.8 | 1.80 | Kutter, p. 139 |
| 5 | 4.00 | Steel | Speller | 1917 | 152 | 3.3–10.0 | 1.95 | |
| 6 | 5.00 | Brass | Schoder and Gehring | 1906 | 142 | 1.0–10.0 | 1.79 | E. Rec., 58; 241 |
| 7 | 6.00 | Steel | Speller | 1917 | 145 | 1.0–10.0 | 1.91 | |
| 8 | 6.00 | W. I. | Schoder and Gehring | 1906 | 145 | 7.0–18.0 | 1.94 | E. Rec., 58; 241 |
| 9 | 7.75 | W. I. | Darcy | 1851 | 138 | 1.0–10.0 | 1.79 | Kutter; p. 141 |
| 10 | 8.00 | Steel | Speller | 1917 | 153 | 1.0–10.0 | 1.92 | |
| 11 | 8.00 | C. I. | Speller | 1917 | 144 | 1.0– 9.0 | 2.00 | |
| 12 | 8.00 | Wood | Moritz | 1910 | 147 | 0.4– 6.0 | 1.71 | Am. Soc; 74; 411 |
| 13 | 11.2 | W. I. | Darcy | 1851 | 138 | 1.3–10.5 | 1.85 | Kutter, p. 141 |
| 14 | 12.0 | C. I. | Williams, Hubbell and Fenkell | 1901 | 133 | 1.0– 5.0 | 1.78 | Am. Soc., 47; 1 |
| 15 | 16.0 | C. I. | " " " | 1901 | 146 | 1.0– 5.0 | 1.85 | Am. Soc., 47; 1 |
| 16 | 48 | C. I. | Stearns | 1880 | 143 | 2.6– 6.2 | 1.91 | Am. Soc., 14; 4 |
| 17 | 48 | C. I. | FitzGerald | 1894 | 143 | 1.0– 7.0 | 1.91 | Am. Soc., 35; 241 |

exponents previously stated for the same data. The data, bearing upon the exponent of $s$, are shown in Table 1.

In this table four results attributed to F. N. Speller have not previously been published. These relate to experiments made at McKeesport, Penn., in 1917. The steel pipes used in experiments Numbers 5, 7, and 10 were rolled at a temperature so low that mill scale did not form; and were as smooth as brass pipe. They were laid perfectly straight; flows were measured by Venturi meter, and the loss of head in two straight runs of 1000 ft. parallel with each other, one out and one back, were measured by differential gauges attached at four points, each about 104 ft. from an end or turn. In one case, No. 11 of the table, cast-iron pipe was used, but otherwise the conditions of the tests were the same.

Of the seventeen series of experiments now selected, ten have been made since the Williams-Hazen formula was proposed in 1902.

The average of the seventeen values is 0.538. Taking the results for 8-inch pipe and over as being perhaps a safer guide for use in calculations for large pipes, the average is found to be 0.536. In other words, in these selected data pipes from 2 to 7.75 inches in diameter give practically the same indications as do the larger pipes. The values for three pipes of brass and wood, taken by themselves, average 0.572, while the fourteen remaining ones, representing pipes of iron and steel, average 0.531.

These results are not far from the value used in the Williams-Hazen formula, which is 0.54. No revision of this value appears to be necessary.

For rough pipes the value of the exponent $s$ is lower, but seldom or never lower than 0.50. Perhaps 0.52 would be a representative value for old pipe. Practically the one value of the formula is close enough for general use.

## EXPONENT OF $r$.

This exponent indicates the rate of increase in velocity with hydraulic radius (or diameter) at a constant slope.

In order to study the Exponent of $r$, comparison must be made of the records of pipes of different sizes. In making comparison it is not easy to be sure that the large pipes and small pipes that are compared are really of equal smoothness. Perhaps the safest procedure is to compare the very smoothest pipes of all sizes by themselves, regardless of material. To do this, data showing the highest coefficients known to the authors are selected. Comparison is made by plotting the values of the coefficients in the Williams-Hazen formula on logarithmic paper.

By making the logarithmic scale ten times greater in one direction than the other the differences are exaggerated and the results are spread out so as to allow a great variety of results to be adequately shown without crowding. Such a plotting of the values of $c$ is presented in plate I.

The value of $c$ for any one pipe does not usually vary much with velocity; and if the exponent of $s$ is correct, the variation should be as often in one direction as in the other. But sometimes there are variations, and to make sure of having all the data on a comparable basis, this diagram represents only conditions with velocities falling between 3 to 3.5 feet per second.

Selecting the values of $c$ in this way has the result of using as a starting point a velocity of about 3.25 feet or approximately one meter per second. This is believed to be a safer procedure than the usual one of using a velocity of one foot per second as a base, because one foot per second is below the ordinary velocities of practical use for which estimates are made; and viscosity may play a greater part in the results at that velocity than it does in the higher velocities of ordinary practice.

In Table 2 are listed those experiments, plotted in Plate I, which show the highest values of $c$, and which are, therefore, most important for our present purpose.

In Plate 1 and Table 2 a number of results are shown for pipe less than 2 inches in diameter. These are shown for completeness and interest; but because viscosity may exert a greater influence in them, they should be disregarded so far as they differ from the indications for larger pipe, when a formula for use with larger pipe is being considered.

If these data were exactly in accord with Williams-Hazen formula, then the coefficient for the smoother pipes large and small would lie in one horizontal line at the top. The smoothest pipes actually come near to doing this. Plotted on a scale without the 10 to 1 exaggeration this lining up would be more striking. If instead of being horizontal the general slope of the limiting line of highest results is upward to the right, it indicates a higher value of the exponent of $R$ than the 0.63 of the formula, while a slope in the other direction would indicate a lower value.

For the purpose of aiding judgment two lines have been drawn corresponding to values of 0.62 and 0.64; that is to say, with one point variation either way from the value of 0.63 used in the W. & H. formula.

The exponent of 0.63 means that with a fixed slope, and equal smoothness of pipe wall, the velocity will increase as the 0.63 power of the diameter. But as our plotting is made for a fixed velocity, it may be more accurately stated the other way about: The friction will decrease with increasing pipe size in the ratio of the two exponents in the formula 0.54 and 0.63 or as the inverse 1.167 power of the diameter. In similar

## TABLE 2.—EXPONENT OF RADIUS.

| Number. | Diameter. | Kind. | Authority. | Approximate Date of Experiment. | Value of $c$ when $v=3.28$. | Reference. |
|---|---|---|---|---|---|---|
| 1 | 8 | Steel | Speller | 1917 | 153 | |
| 2 | 55.75 | Wood | Moritz | 1909 | 152 | Am. Soc. C. E., 74; 411 |
| 3 | 4 | Steel | Speller | 1917 | 152 | |
| 4 | 48 | Wood | Scobey | 1914 | 150 | U. S. Dept. Agri. Bt., 376 |
| 5 | 48.75 | Wood | Moore | 1911 | 150 | Am. Soc. C. E., 74; 463 |
| 6 | 42 | Cement | Rust | 1915 | 148 | Eng. News., 74; 997 |
| 7 | 1.45 | Brass | Saph and Schoder | 1903 | 147 | Am. Soc. C. E., 51; 253 |
| 8 | 8 | Wood | Moritz | 1910 | 147 | " " " 74; 411 |
| 9 | 61 | Cast Iron | FitzGerald | 1900 | 147 | " " " 44; 88 |
| 10 | 1.42 | Tin | Bossut | 1771 | 145 | Kutter, p. 1[illegible] |
| 11 | 6 | Steel | Speller | 1917 | 145 | |
| 12 | 6 | W. I. | Schoder and Gehring | 1906 | 145 | Eng. Rec., 58; 241 |
| 13 | 162 | Wood | Scobey | 1914 | 145 | U. S. Dept. Agri. Btn. 376 |
| 14 | 2.06 | W. I. | Davis | 1908 | 144 | Am. Soc. C. E., 69; 97 |
| 15 | 8 | W. I. | Speller | 1917 | 144 | |
| 16 | 110 | Syphon | Moore | 1915 | 144 | Catskill Aqueduct |
| 17 | 30 | Cement | Newell | 1911 | 144 | Eng. News., 69; 904 |
| 18 | 46 | Cement | Newell | 1911 | 144 | " " 69; 904 |
| 19 | 2.09 | Brass | Saph and Schoder | 1903 | 143 | Am. Soc. C. E., 51; 253 |
| 20 | 44 | C. I. | Barnes | 1914 | 143 | Barnes Hyd. Flow Reviewed |

## TABLE 2.—EXPONENT OF RADIUS—(*Continued*).

| Number. | Diameter. | Kind. | Authority. | Approximate Date of Experiment. | Value of $c$ when $v = 3.28$. | Reference. |
|---|---|---|---|---|---|---|
| 21 | 48 | C. I. | Stearns | 1880 | 143 | Am. Soc. C. E., 14; 4 |
| 22 | 48 | C. I. | FitzGerald | 1894 | 143 | " " " 35; 261 |
| 23 | 2.14 | Tin | Bossut | 1771 | 142 | Kutter, p. 134 |
| 24 | 5 | Brass | Schoder and Gehring | 1906 | 142 | E. Rec., 58; 241 |
| 25 | 18 | Wood | Moritz | 1910 | 142 | Am. Soc. C. E., 74; 411 |
| 26 | 40 | C. I. | Barnes | 1914 | 142 | Barnes Hyd. flow rev'd |
| 27 | 48 | C. I. | Bruce | 1896 | 141 | Proc. Inst. C. E., 123 |
| 28 | 1.25 | Wood | Alexander | ........... | 140 | " " " 159 |
| 29 | 3.25 | W. I. | Darcy | 1851 | 140 | Kutter, p. 139 |
| 30 | 36 | Lock Bar | Montreal | 1913 | 140 | Private Information |
| 31 | 1.05 | Brass | Saph and Schoder | 1903 | 139 | Am. Soc. C. E., 51; 253 |
| 32 | 1.24 | Brass | Saph and Schoder | 1903 | 139 | " " " 51; 253 |
| 33 | 7.75 | W. I. | Darcy | 1851 | 138 | Kutter, p. 141 |
| 34 | 1.5 | Lead | Provis | 1838 | 137 | Proc. Inst. C. E., 1838 |
| 35 | 0.82 | Brass | Saph and Schoder | 1903 | 137 | Am. Soc. C. E., 51; 253 |
| 36 | 0.92 | Glass | Hamilton Smith | 1882 | 137 | Am. Soc. C. E., 12; 119 |
| 37 | 1.06 | Lead | Darcy | 1851 | 136 | Kutter, p. 135 |
| 38 | 174 | Tunnel | Moore | 1915 | 136 | Catskill Aqueduct. |

way the line marked 0.62 corresponds to an exponent of 1.148 in the other forms of statement and the line marked 0.64 corresponds to an exponent of 1.185.

Abundant and accurate data (not here shown) indicate that for pipes less than 1 inch in diameter the exponent of $r$ is greater than 0.63. Saph and Schoder's experiments on the flow of water in small brass pipes are among these. For such pipes, the Saph and Schoder formula is better. If the Williams-Hazen formula is used, it must be borne in mind that, owing to the influence of viscosity, the flows in such pipes may be as much as 10 per cent less than would otherwise be expected, and coefficients correspondingly smaller are to be used.

A few data for 6- and 8-inch extremely smooth pipes are almost in line with the data for small brass pipes; and if we had no records of the flow in still larger pipe, it might be thought that the Saph and Schoder formula was applicable to pipe of all sizes. But for larger pipe our best data indicate a lower value of the exponent of $r$. The highest coefficients for pipes above two inches in diameter as plotted are not far from level at the top of the diagram. Perhaps an inclination corresponding to an exponent of 0.64 would come nearer to representing the data for pipes from 2 to 60 inches in diameter. But for still larger pipes there are instances of pipes believed to be exceedingly smooth that show lower values. Scanty data for such large pipes indicate a value that is lower than 0.63.

The question of the best exponent to use for large pipe could be settled conclusively by a series of experiments on large pipe like those that Saph and Schoder made on small ones. The diameters of the pipes might be 100 times greater; the velocities might remain the same. The quantities of water to be measured would then be 10,000 times greater than those used by Saph and Schoder. The difficulties of such experiments are obvious, and unfortunately there is no reason to expect that such tests will be made in the near future. For the present we can only make the best use of such data as we have.

Taking it all together, the old formula as proposed 18 years ago is about as near right in its exponents as it can be made to-day. Certainly there is no clear-cut indication, in the more abundant present data, that a change is desirable.

## COEFFICIENTS.

The coefficient is an index of the smoothness of the interior of the pipe surface. As a practical matter the coefficient to be used in any estimate is a matter of more concern than the exponents. Some data

as to the coefficients for different kinds of pipe and for open channels, accumulated since the first edition of these tables are now added to the tables. In general, the added data and the experience with the use of the formula do not suggest considerable changes in the coefficients that were first recommended.

For new cast-iron pipe 130 remains the appropriate value; but 140 is sometimes reached, and there is a record o one pipe with a value of 147.

Some kinds of pipe are smoother than cast-iron pipe. Wood pipe has been made very smooth. Of metal pipes, brass and tin are the smoothest and have given the highest coefficients; but steel, rolled below the temperature at which mill scale is formed, is almost equal in smoothness to brass. Cement pipe, poured in steel moulds, sometimes has a finish almost as smooth as glass. Experiments Numbers 6, 16, 17, 18 and 38 in Table 2 represent such pipes. The tests were made in each case when the pipe was quite new. Unfortunately, the extreme smoothness is not durable; and subsequent experiments on the same pipes in several cases have given lower coefficients.

These three kinds of pipe, wood, rolled metal and cement cast against rolled metal, when new and perfectly clean, give coefficients up to 145 and 150; and in three cases to 152 and 153. These represent the smoothest pipe so far tested. On the other hand various other kinds of pipe and old pipe are less smooth and give lower coefficients.

## COEFFICIENTS OF OLD PIPES.

Most pipe in actual use is of iron or steel, and such pipe always deteriorates in carrying capacity with age. The rate of deterioration depends upon three conditions; first, the quality of the metal; second the excellence of the pipe coating; and third, the quality of the water.

At the top of the pages of Hydraulic Tables are shown heavy faced figures, enclosed in circles representing the ages in years at which it is supposed on an average iron pipes would reach the coefficients indicated. These are intended to serve as a warning to the estimator of the reduced capacity to be faced with age, and as a guide in making allowance for it.

Since the first edition, many added data have accumulated, but these are not of a kind to be easily arranged for presentation in concise form.

In general it may be stated that rather large deviations from the indicated rates of reduction in carrying capacity are found in individual cases, but that, in the experience of the authors, the variations are

about as often in one direction as in the other. The figures are believed to be useful as a general indication of probable conditions.

The following instances may be of interest:

A 24-inch cast-iron pipe, twenty-three years old, carrying Lake Michigan water, through which a fair velocity was always maintained, was found to have a coefficient of 118. The deterioration actually found was that indicated by the tables for a pipe of one-third its age. Other data indicate that pipes carrying moderately hard but clear waters from the Great Lakes and other large clean lakes will lose their capacity but slowly.

Raw or untreated river waters of average turbidity, from which the heaviest sediment has been removed by settling, may be expected to follow more closely the indications of the figures. Pipes carrying filtered water may be expected to deteriorate less rapidly than pipes carrying raw water.

On the other hand, when water is treated chemically the equilibrium of its mineral constituents is sometimes disturbed in a way to increase the corrosion of the pipe through which it flows, and to reduce carrying capacity more rapidly. In a similar way water carrying saline matters, as for instance, dilute sea-water, encourages tuberculation and tends to more rapid reduction in carrying capacity.

In one water works system tests of representative pipes of various ages by measuring the flows with pitometer and the frictions by differential gauges have been made. The water was clear, soft, unfiltered water from impounding reservoirs with some admixtures of harder ground water. Eight-inch pipes of many ages up to fifty years were tested. The reductions in carrying capacity were found on an average to correspond fairly well with the figures in the circles of the tables.

In another system where the mineral contents of the water had been higher, similar tests of pipes up to thirty years old showed that the reduction in capacity was considerably more rapid than indicated.

Muddy river waters sometimes deposit sediment in pipes in which there is but little flow and so lose their carrying capacity with a rapidity for which no rule can be suggested. And a few waters have been noted capable of forming deposits of calcium carbonate on the interiors of the pipes, reducing their sections and making them rougher.

The quality of metal in the pipe and the excellence of coating have much to do with the rapidity of corrosion and loss of capacity. Large riveted pipes of wrought iron, with a double coating of a mixture of coal tar and asphalt, the first coating put on very hot and thin for adhesion, and the second less hot and thicker for durability have been found in some cases to have lost but little of their original carrying capacity

after thirty or forty years. Interior inspection of these pipes shows hardly any tuberculation and but few blisters. Other pipes of equal quality, so far as known, have shown reductions in carrying capacity corresponding approximately with the figures in the circles.

The problem is too complicated for one to estimate with accuracy what the carrying capacity of old pipe will be. Whenever the carrying capacity of an old pipe becomes important, the one sure way is to make a test of it by pitometer or otherwise, and determine its coefficient.

Looking to the future, it is not unreasonable to hope that improved pipe coating may be found that will materially lessen deterioration with age.

# SMALL BRASS PIPES.

$c = 130.$

MAY ALSO BE USED FOR STRAIGHT LEAD, TIN, AND DRAWN-COPPER PIPES.

| Diameter in Inches. | Gallons Daily for $v=1$ Ft. per Second. | Loss of Head in Feet per 1000 feet of length. | | | | | |
|---|---|---|---|---|---|---|---|
| | | $v=0.5'$ | $v=1.0'$ | $v=2.0'$ | $v=3.0'$ | $v=4.0'$ | $v=5.0'$ |
| 0.03 | 3.2 | *1170* | *2350* | *4700* | *7050* | *9400* | *11700* |
| 0.04 | 5.6 | *660* | *1310* | *2620* | *3940* | *5250* | *6600* |
| 0.05 | 8.8 | *420* | *840* | *1680* | *2520* | *3370* | 4350 |
| 0.06 | 12.7 | *290* | *580* | *1170* | *1750* | *2340* | 3520 |
| 0.07 | 17.3 | *215* | *430* | *860* | *1290* | 1930 | 2950 |
| 0.08 | 22.6 | *164* | *330* | *660* | *990* | 1650 | 2500 |
| 0.09 | 28.5 | *130* | *260* | *520* | 840 | 1440 | 2200 |
| 0.10 | 35.3 | *105* | *210* | *420* | 750 | 1270 | 1940 |
| 0.11 | 42.7 | *87* | *174* | *350* | 670 | 1140 | 1730 |
| 0.12 | 51 | *73* | *146* | *293* | 605 | 1030 | 1560 |
| 0.14 | 69 | *54* | *108* | 239 | 505 | 860 | 1310 |
| 0.16 | 90 | *41* | *82* | 202 | 430 | 740 | 1120 |
| 0.18 | 114 | *32* | *65* | 178 | 375 | 640 | 980 |
| 0.20 | 141 | *26* | *52* | 157 | 333 | 570 | 860 |
| 0.22 | 171 | *21* | *43* | 141 | 300 | 510 | 770 |
| 0.24 | 203 | *18* | *36* | 127 | 270 | 460 | 700 |
| 0.26 | 238 | *15* | 32 | 116 | 245 | 418 | 640 |
| 0.28 | 277 | *13* | 30 | 106 | 225 | 382 | 580 |
| 0.30 | 317 | *12* | 27 | 98 | 209 | 354 | 540 |
| 0.35 | 432 | *9* | 23 | 83 | 175 | 299 | 450 |
| 0.40 | 564 | *7* | 19 | 70 | 149 | 252 | 385 |
| 0.45 | 714 | *5* | 17 | 61 | 130 | 220 | 335 |
| 0.50 | 880 | 4.15 | 15 | 54 | 114 | 195 | 295 |
| 0.55 | 1,070 | 3.75 | 13.4 | 48 | 102 | 174 | 265 |
| 0.60 | 1,270 | 3.35 | 12.1 | 44 | 92 | 157 | 240 |
| 0.65 | 1,490 | 3.07 | 11.0 | 40 | 84 | 144 | 220 |
| 0.70 | 1,730 | 2.80 | 10.1 | 36 | 77 | 132 | 200 |
| 0.75 | 1,990 | 2.59 | 9.4 | 34 | 71 | 121 | 184 |
| 0.80 | 2,260 | 2.40 | 8.7 | 31 | 66 | 113 | 170 |
| 0.85 | 2,550 | 2.23 | 8.1 | 29 | 62 | 105 | 159 |
| 0.90 | 2,860 | 2.10 | 7.6 | 27 | 58 | 98 | 148 |
| 0.95 | 3,180 | 1.96 | 7.1 | 26 | 54 | 92 | 139 |
| 1.00 | 3,525 | 1.85 | 6.7 | 24 | 51 | 87 | 131 |
| 1.10 | 4,250 | 1.65 | 6.0 | 21 | 46 | 78 | 117 |
| 1.20 | 5,080 | 1.50 | 5.4 | 19 | 41 | 70 | 106 |

*Note.*—Figures in italics are below the critical velocity and are computed by the formula $v = 475sd^2\left(\frac{t+10}{60}\right)$. $t$ (temperature) is taken as 50° F.

# SMALL PIPE.

## WROUGHT-IRON-PIPE SIZES.

| Nominal Size, Inches. | Actual Diameter, Inches. | Discharge in Gallons. | | Velocity, Feet per Second. | Loss of Head in Feet per 1000 feet of length. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Per Minute. | Per 24 Hours. | | Very Smooth and Straight. $c=140$ | Smooth New Iron. $c=120$ | Ordinary Iron. $c=100$ | Old Iron. $c=80$ | Very Rough. $c=60$ |
| $\frac{1}{8}$ | 0.270 | 0.2 | 288 | 1.12 | 33 | 44 | 62 | 94 | 158 |
| | | 0.4 | 576 | 2.24 | 118 | 158 | 220 | 335 | 570 |
| | | 0.6 | 864 | 3.36 | 250 | 335 | 470 | 710 | 1210 |
| | | 0.8 | 1,152 | 4.48 | 430 | 570 | 800 | 1210 | 2050 |
| | | 1.0 | 1,440 | 5.60 | 650 | 860 | 1210 | 1830 | 3100 |
| $\frac{1}{4}$ | 0.364 | 0.5 | 720 | 1.54 | 42 | 56 | 78 | 118 | 200 |
| | | 1.0 | 1,440 | 3.08 | 150 | 200 | 280 | 430 | 730 |
| | | 1.5 | 2,160 | 4.62 | 320 | 425 | 600 | 910 | 1540 |
| | | 2.0 | 2,880 | 6.16 | 550 | 730 | 1030 | 1550 | 2600 |
| | | 2.5 | 3,600 | 7.70 | 830 | 1100 | 1530 | 2320 | 4000 |
| $\frac{3}{8}$ | 0.494 | 1 | 1,440 | 1.67 | 34 | 46 | 64 | 97 | 165 |
| | | 2 | 2,880 | 3.35 | 125 | 167 | 233 | 350 | 600 |
| | | 3 | 4,320 | 5.02 | 260 | 350 | 490 | 740 | 1260 |
| | | 4 | 5,760 | 6.70 | 450 | 600 | 840 | 1260 | 2150 |
| | | 5 | 7,200 | 8.37 | 680 | 900 | 1260 | 1900 | 3250 |
| $\frac{1}{2}$ | 0.623 | 1 | 1,440 | 1.05 | 11 | 15 | 21 | 31 | 53 |
| | | 2 | 2,880 | 2.10 | 40 | 53 | 74 | 112 | 192 |
| | | 3 | 4,320 | 3.16 | 85 | 113 | 158 | 240 | 410 |
| | | 4 | 5,760 | 4.21 | 145 | 192 | 270 | 410 | 700 |
| | | 5 | 7,200 | 5.26 | 220 | 290 | 410 | 620 | 1050 |
| | | 6 | 8,640 | 6.31 | 310 | 410 | 570 | 870 | 1470 |
| | | 7 | 10,080 | 7.37 | 410 | 540 | 760 | 1150 | 1950 |
| | | 8 | 11,520 | 8.42 | 520 | 700 | 980 | 1480 | 2500 |
| | | 9 | 12,960 | 9.47 | 650 | 860 | 1210 | 1830 | 3100 |
| | | 10 | 14,400 | 10.52 | 790 | 1050 | 1470 | 2230 | 3800 |
| $\frac{3}{4}$ | 0.824 | 2 | 2,880 | 1.20 | 10 | 14 | 19 | 29 | 49 |
| | | 3 | 4,320 | 1.80 | 22 | 29 | 41 | 61 | 105 |
| | | 4 | 5,760 | 2.41 | 37 | 50 | 70 | 105 | 180 |
| | | 5 | 7,200 | 3.01 | 56 | 75 | 105 | 159 | 270 |
| | | 6 | 8,640 | 3.61 | 79 | 105 | 147 | 224 | 380 |
| | | 8 | 11,520 | 4.81 | 135 | 180 | 250 | 380 | 650 |
| | | 10 | 14,400 | 6.02 | 205 | 271 | 380 | 580 | 980 |
| | | 12 | 17,280 | 7.22 | 285 | 380 | 530 | 800 | 1370 |
| | | 15 | 21,600 | 9.02 | 430 | 570 | 800 | 1220 | 2030 |
| | | 20 | 28,800 | 12.03 | 730 | 970 | 1360 | 2060 | 3500 |

# SMALL PIPE.

## WROUGHT-IRON-PIPE SIZES.

| Nominal Size, Inches. | Actual Diameter, Inches. | Discharge in Gallons. | | Velocity, Feet per Second. | Loss of Head in Feet per 1000 feet of length. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Per Minute. | Per 24 Hours. | | Very Smooth and Straight. $c=140$ | Smooth New Iron. $c=120$ | Ordinary Iron. $c=100$ | Old Iron. $c=80$ | Very Rough. $c=60$ |
| 1 | 1.048 | 3 | 4,320 | 1.12 | 6.8 | 9.0 | **12.6** | 19.0 | 32 |
| | | 4 | 5,760 | 1.49 | 11.5 | 15.2 | **21.4** | 32.3 | 55 |
| | | 5 | 7,200 | 1.86 | 17.5 | 23.2 | **32.5** | 49.1 | 84 |
| | | 6 | 8,640 | 2.23 | 24.5 | 32.5 | **45.5** | 69 | 117 |
| | | 8 | 11,520 | 2.98 | 42.0 | 55 | **78** | 117 | 200 |
| | | 10 | 14,400 | 3.72 | 63 | 84 | **117** | 177 | 300 |
| | | 12 | 17,280 | 4.46 | 88 | 117 | **164** | 250 | 420 |
| | | 14 | 20,160 | 5.20 | 117 | 155 | **220** | 330 | 560 |
| | | 16 | 23,040 | 5.95 | 150 | 200 | **280** | 420 | 720 |
| | | 18 | 25,920 | 6.69 | 185 | 250 | **350** | 520 | 890 |
| | | 20 | 28,800 | 7.44 | 226 | 301 | **420** | 640 | 1090 |
| | | 25 | 36,000 | 9.30 | 340 | 455 | **640** | 960 | 1640 |
| | | 30 | 43,200 | 11.15 | 480 | 640 | **890** | 1350 | 2300 |
| | | 35 | 50,400 | 13.02 | 640 | 850 | **1190** | 1800 | 3080 |
| | | 40 | 57,600 | 14.88 | 820 | 1090 | **1520** | 2300 | 3900 |
| $1\frac{1}{4}$ | 1.380 | 4 | 5,760 | 0.86 | 3.0 | 4.0 | **5.7** | 8.6 | 14.5 |
| | | 5 | 7,200 | 1.07 | 4.5 | 6.0 | **8.4** | 12.7 | 21.8 |
| | | 6 | 8,640 | 1.29 | 6.4 | 8.6 | **12.0** | 18.2 | 31 |
| | | 7 | 10,080 | 1.50 | 8.5 | 11.4 | **15.9** | 24 | 41 |
| | | 8 | 11,520 | 1.72 | 11.0 | 14.5 | **20.3** | 31 | 53 |
| | | 10 | 14,400 | 2.14 | 16.5 | 21.8 | **30.5** | 46 | 79 |
| | | 12 | 17,280 | 2.57 | 23.0 | 30.8 | **43** | 65 | 110 |
| | | 14 | 20,160 | 3.00 | 30.8 | 41 | **57** | 87 | 148 |
| | | 16 | 23,040 | 3.43 | 39.2 | 52 | **73** | 111 | 189 |
| | | 18 | 25,920 | 3.86 | 49 | 65 | **91** | 137 | 235 |
| | | 20 | 28,800 | 4.29 | 60 | 79 | **111** | 168 | 286 |
| | | 25 | 36,000 | 5.36 | 89 | 119 | **166** | 251 | 430 |
| | | 30 | 43,200 | 6.43 | 126 | 169 | **235** | 358 | 610 |
| | | 35 | 50,400 | 7.51 | 168 | 223 | **312** | 470 | 800 |
| | | 40 | 57,600 | 8.58 | 214 | 285 | **400** | 610 | 1030 |
| | | 50 | 72,000 | 10.72 | 325 | 432 | **600** | 920 | 1560 |
| | | 60 | 86,400 | 12.87 | 450 | 610 | **850** | 1290 | 2200 |
| | | 70 | 100,800 | 15.01 | 610 | 810 | **1130** | 1700 | 2900 |
| | | 80 | 115,200 | 17.16 | 780 | 1030 | **1450** | 2200 | 3700 |
| | | 90 | 129,600 | 19.30 | 960 | 1280 | **1800** | 2700 | 4600 |

# 1½-INCH WROUGHT-IRON PIPE.

(Actual Diameter, 1.611.)

| Discharge in Gallons. | | Velocity, Feet per Second. | Loss of Head in Feet per 1000 feet of length | | | | |
|---|---|---|---|---|---|---|---|
| Per Minute. | Per 24 Hours. | | Very Smooth and Straight. $c=140$ | Smooth New Iron. $c=120$ | Ordinary Iron. $c=100$ | Old Iron. $c=80$ | Very Rough. $c=60$ |
| 4 | 5,760 | 0.63 | 1.42 | 1.87 | **2.62** | 4.0 | 6.8 |
| 5 | 7,200 | 0.79 | 2.13 | 2.83 | **3.98** | 6.0 | 10.3 |
| 6 | 8,640 | 0.94 | 2.98 | 3.98 | **5.6** | 8.4 | 14.3 |
| 7 | 10,080 | 1.10 | 3.97 | 5.3 | **7.4** | 11.2 | 19.2 |
| 8 | 11,520 | 1.26 | 5.1 | 6.8 | **9.5** | 14.3 | 24.2 |
| 9 | 12,960 | 1.42 | 6.3 | 8.4 | **11.8** | 17.9 | 30.6 |
| 10 | 14,400 | 1.57 | 7.7 | 10.2 | **14.3** | 21.7 | 36.6 |
| 12 | 17,280 | 1.89 | 10.8 | 14.3 | **20.1** | 30.4 | 52 |
| 14 | 20,160 | 2.20 | 14.3 | 19.1 | **26.8** | 40.5 | 69 |
| 16 | 23,040 | 2.52 | 18.3 | 24.4 | **34.1** | 52 | 88 |
| 18 | 25,920 | 2.83 | 22.8 | 30.2 | **42.4** | 64 | 109 |
| 20 | 28,800 | 3.15 | 27.8 | 37 | **52** | 78 | 134 |
| 22 | 31,680 | 3.46 | 33.0 | 44 | **62** | 93 | 159 |
| 24 | 34,560 | 3.78 | 38.8 | 52 | **73** | 108 | 185 |
| 26 | 37,440 | 4.09 | 45.1 | 60 | **84** | 127 | 217 |
| 28 | 40,320 | 4.41 | 52 | 69 | **97** | 146 | 248 |
| 30 | 43,200 | 4.72 | 59 | 78 | **110** | 166 | 282 |
| 35 | 50,400 | 5.51 | 78 | 103 | **147** | 220 | 374 |
| 40 | 57,600 | 6.30 | 100 | 133 | **188** | 281 | 480 |
| 45 | 64,800 | 7.08 | 124 | 166 | **232** | 350 | 600 |
| 50 | 72,000 | 7.87 | 152 | 202 | **284** | 428 | 730 |
| 55 | 79,200 | 8.66 | 181 | 240 | **340** | 510 | 870 |
| 60 | 86,400 | 9.44 | 212 | 281 | **396** | 600 | 1020 |
| 65 | 93,600 | 10.23 | 246 | 328 | **459** | 700 | 1180 |
| 70 | 100,800 | 11.02 | 282 | 376 | **530** | 800 | 1360 |
| 75 | 108,000 | 11.80 | 321 | 427 | **600** | 900 | 1540 |
| 80 | 115,200 | 12.59 | 361 | 480 | **680** | 1020 | 1730 |
| 85 | 122,400 | 13.38 | 405 | 540 | **750** | 1140 | 1940 |
| 90 | 129,600 | 14.17 | 450 | 600 | **840** | 1260 | 2140 |
| 95 | 136,800 | 14.95 | 498 | 660 | **930** | 1400 | 2390 |
| 100 | 144,000 | 15.74 | 550 | 730 | **1020** | 1540 | 2620 |
| 110 | 158,400 | 17.31 | 650 | 870 | **1220** | 1840 | 3120 |
| 120 | 172,800 | 18.89 | 770 | 1020 | **1430** | 2170 | 3690 |
| 130 | 187,200 | 20.46 | 890 | 1180 | **1660** | 2500 | 4260 |
| 140 | 201,600 | 22.04 | 1020 | 1360 | **1900** | 2880 | 4890 |

# 2-INCH PIPE OR HOSE.

(Actual diameter, 2.00 ins.)

| Discharge in Gallons. | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Per Minute. | Per 24 Hours. | | | Very Smooth and Straight Brass, Tin, etc. $c=140$ | Ordinary Straight Brass, Tin, etc. $c=130$ | Smooth New Iron. $c=120$ | Ordinary Iron. $c=100$ | Old Iron. $c=80$ | Very Rough. $c=60$ | Badly Tuberculated. $c=40$ |
| 6 | 8,640 | 0.61 | 0.01 | 1.0 | 1.2 | 1.4 | **2.0** | 2.9 | 5.0 | 10.7 |
| 8 | 11,520 | 0.82 | 0.01 | 1.8 | 2.0 | 2.4 | **3.3** | 5.0 | 8.6 | 18.2 |
| 10 | 14,400 | 1.02 | 0.02 | 2.7 | 3.1 | 3.6 | **5.0** | 7.6 | 12.9 | 27.4 |
| 12 | 17,280 | 1.23 | 0.02 | 3.8 | 4.3 | 5.0 | **7.0** | 10.7 | 18.1 | 38.5 |
| 14 | 20,160 | 1.43 | 0.03 | 5.0 | 5.8 | 6.7 | **9.4** | 14.2 | 24.1 | 51 |
| 16 | 23,040 | 1.63 | 0.04 | 6.4 | 7.4 | 8.6 | **12.0** | 18.2 | 30.9 | 66 |
| 18 | 25,920 | 1.84 | 0.05 | 8.0 | 9.2 | 10.7 | **14.9** | 22.7 | 38.6 | 82 |
| 20 | 28,800 | 2.04 | 0.06 | 9.8 | 11.2 | 12.9 | **18.2** | 27.5 | 46.8 | 99 |
| 25 | 36,000 | 2.55 | 0.10 | 14.8 | 16.9 | 19.6 | **27.3** | 41.6 | 71 | 150 |
| 30 | 43,200 | 3.06 | 0.15 | 20.7 | 23.8 | 27.3 | **38.4** | 58 | 99 | 210 |
| 35 | 50,400 | 3.57 | 0.20 | 27.5 | 31.5 | 36.6 | **51** | 78 | 132 | 280 |
| 40 | 57,600 | 4.08 | 0.26 | 35.1 | 40.2 | 46.8 | **66** | 99 | 168 | 359 |
| 45 | 64,800 | 4.60 | 0.33 | 43.8 | 50 | 58 | **82** | 123 | 210 | 446 |
| 50 | 72,000 | 5.11 | 0.40 | 53 | 61 | 71 | **99** | 150 | 257 | 540 |
| 55 | 79,200 | 5.62 | 0.49 | 64 | 73 | 84 | **118** | 179 | 305 | 640 |
| 60 | 86,400 | 6.13 | 0.58 | 74 | 86 | 99 | **139** | 210 | 359 | 760 |
| 65 | 93,600 | 6.64 | 0.68 | 86 | 99 | 115 | **161** | 244 | 416 | 880 |
| 70 | 100,800 | 7.15 | 0.79 | 99 | 114 | 132 | **184** | 280 | 477 | 1010 |
| 75 | 108,000 | 7.66 | 0.91 | 113 | 129 | 149 | **209** | 318 | 540 | 1150 |
| 80 | 115,200 | 8.17 | 1.04 | 127 | 146 | 169 | **237** | 358 | 610 | 1280 |
| 90 | 129,600 | 9.19 | 1.31 | 158 | 182 | 210 | **294** | 447 | 760 | 1610 |
| 100 | 144 000 | 10.21 | 1.62 | 192 | 220 | 256 | **358** | 540 | 920 | 1960 |
| 110 | 158,400 | 11.23 | 1.96 | 230 | 262 | 306 | **429** | 650 | 1110 | 2330 |
| 120 | 172,800 | 12.25 | 2.33 | 271 | 310 | 360 | **500** | 760 | 1300 | 2760 |
| 130 | 187,200 | 13.28 | 2.73 | 312 | 360 | 418 | **580** | 880 | 1510 | 3190 |
| 140 | 201,600 | 14.30 | 3.17 | 360 | 413 | 479 | **670** | 1020 | 1730 | 3670 |
| 150 | 216,000 | 15.32 | 3.64 | 407 | 465 | 540 | **760** | 1140 | 1950 | 4180 |
| 160 | 230,400 | 16.34 | 4.14 | 460 | 530 | 610 | **860** | 1290 | 2210 | 4690 |
| 170 | 244,800 | 17.36 | 4.67 | 520 | 590 | 690 | **960** | 1460 | 2480 | 5300 |
| 180 | 259,200 | 18.38 | 5.23 | 570 | 650 | 760 | **1070** | 1620 | 2730 | 5800 |
| 190 | 273,600 | 19.40 | 5.84 | 630 | 720 | 840 | **1180** | 1780 | 3030 | 6400 |
| 200 | 288,000 | 20.42 | 6.46 | 690 | 800 | 920 | **1290** | 1960 | 3330 | 7100 |
| 220 | 316,800 | 22.47 | 7.82 | 830 | 950 | 1110 | **1540** | 2340 | 3990 | 8400 |
| 240 | 345,600 | 24.51 | 9.31 | 980 | 1120 | 1300 | **1820** | 2760 | 4700 | 9900 |
| 260 | 374,400 | 26.55 | 10.90 | 1130 | 1290 | 1510 | **2110** | 3190 | 5400 | 11500 |

# 2½-INCH PIPE OR HOSE.

(Actual diameter, 2.50 ins.)

| Discharge in Gallons. | | Velocity in Feet per Second | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Per Minute. | Per 24 Hours. | | | Very Smooth and Straight Brass, Tin, etc. $c=140$ | Ordinary Straight Brass, Tin, etc. $c=130$ | Smooth New Iron. $c=120$ | Ordinary Iron. $c=100$ | Old Iron. $c=80$ | Very Rough. $c=60$ | Badly Tuberculated. $C=40$ |
| 8 | 11,250 | 0.52 | 0.00 | 0.6 | 0.7 | 0.8 | **1.1** | 1.7 | 2.9 | 6.1 |
| 10 | 14,400 | 0.65 | 0.01 | 0.9 | 1.0 | 1.2 | **1.7** | 2.6 | 4.3 | 9.2 |
| 12 | 17,280 | 0.78 | 0.01 | 1.3 | 1.4 | 1.7 | **2.4** | 3.6 | 6.1 | 12.9 |
| 14 | 20,160 | 0.92 | 0.01 | 1.7 | 2.0 | 2.3 | **3.2** | 4.7 | 8.2 | 17.4 |
| 16 | 23,040 | 1.05 | 0.02 | 2.2 | 2.5 | 2.9 | **4.1** | 6.2 | 10.5 | 22.2 |
| 18 | 25,920 | 1.18 | 0.02 | 2.7 | 3.1 | 3.6 | **5.0** | 7.6 | 12.9 | 27.3 |
| 20 | 28,800 | 1.31 | 0.03 | 3.3 | 3.8 | 4.3 | **6.1** | 9.2 | 15.7 | 33.2 |
| 25 | 36,000 | 1.63 | 0.04 | 4.9 | 5.7 | 6.6 | **9.2** | 13.9 | 23.7 | 50 |
| 30 | 43,200 | 1.96 | 0.06 | 6.9 | 8.0 | 9.2 | **12.9** | 19.5 | 33.2 | 70 |
| 35 | 50,400 | 2.29 | 0.08 | 9.2 | 10.6 | 12.3 | **17.2** | 26.0 | 44.1 | 94 |
| 40 | 57,600 | 2.61 | 0.11 | 11.8 | 13.5 | 15.7 | **22.0** | 33.2 | 57 | 120 |
| 50 | 72,000 | 3.27 | 0.17 | 17.8 | 20.6 | 23.8 | **33.2** | 51 | 86 | 182 |
| 60 | 86,400 | 3.92 | 0.24 | 24.9 | 28.7 | 33.2 | **46.5** | 70 | 120 | 254 |
| 70 | 100,800 | 4.58 | 0.33 | 33.2 | 38.1 | 44.2 | **62** | 94 | 160 | 338 |
| 80 | 115,200 | 5.23 | 0.43 | 42.5 | 48.8 | 56 | **79** | 120 | 204 | 433 |
| 90 | 129,600 | 5.88 | 0.54 | 53 | 61 | 70 | **98** | 149 | 254 | 540 |
| 100 | 144,000 | 6.54 | 0.66 | 64 | 74 | 86 | **120** | 182 | 309 | 660 |
| 120 | 172,800 | 7.84 | 0.95 | 90 | 103 | 120 | **168** | 254 | 433 | 920 |
| 140 | 201,600 | 9.15 | 1.30 | 120 | 138 | 159 | **223** | 339 | 580 | 1220 |
| 160 | 230,400 | 10.46 | 1.70 | 156 | 178 | 207 | **290** | 440 | 750 | 1570 |
| 180 | 259,200 | 11.76 | 2.15 | 191 | 219 | 254 | **357** | 540 | 920 | 1940 |
| 200 | 288,000 | 13.07 | 2.66 | 232 | 267 | 309 | **431** | 660 | 1120 | 2370 |
| 220 | 316,800 | 14.38 | 3.22 | 277 | 318 | 369 | **520** | 780 | 1330 | 2820 |
| 240 | 345,600 | 15.69 | 3.82 | 330 | 376 | 438 | **610** | 920 | 1570 | 3340 |
| 260 | 374,400 | 16.99 | 4.48 | 378 | 432 | 500 | **700** | 1070 | 1810 | 3860 |
| 280 | 403,200 | 18.30 | 5.20 | 432 | 497 | 580 | **810** | 1220 | 2080 | 4400 |
| 300 | 432,000 | 19.61 | 5.98 | 493 | 570 | 660 | **920** | 1390 | 2370 | 5000 |
| 320 | 460,800 | 20.92 | 6.80 | 560 | 640 | 740 | **1030** | 1570 | 2670 | 5700 |
| 340 | 489,600 | 22.22 | 7.68 | 620 | 710 | 820 | **1160** | 1750 | 2980 | 6400 |
| 360 | 518,400 | 23.53 | 8.60 | 690 | 790 | 920 | **1280** | 1940 | 3310 | 7100 |
| 380 | 547,200 | 24.84 | 9.60 | 780 | 890 | 1020 | **1420** | 2160 | 3670 | 7800 |
| 400 | 576,000 | 26.14 | 10.62 | 840 | 960 | 1120 | **1560** | 2370 | 4020 | 8600 |
| 420 | 604,800 | 27.45 | 11.70 | 920 | 1050 | 1220 | **1710** | 2590 | 4400 | 9300 |
| 440 | 633,600 | 28.76 | 12.85 | 1000 | 1150 | 1330 | **1860** | 2810 | 4800 | 10200 |
| 460 | 662,400 | 30.07 | 14.00 | 1110 | 1260 | 1460 | **2050** | 3100 | 5300 | 11200 |

# 3-INCH PIPE.

(Actual diameter, 3.00 ins.)

| Discharge in Gallons. | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Per Minute. | Per 24 Hours. | | | Very Smooth and Straight Brass, Tin, etc. $c=140$ | Ordinary Straight Brass, Tin, etc. $c=130$ | Smooth New Iron. $c=120$ | Ordinary Iron. $c=100$ | Old Iron. $c=80$ | Very Rough. $c=60$ | Badly Tuberculated. $c=40$ |
| 10 | 14,400 | 0.45 | 0.00 | 0.37 | 0.43 | 0.50 | **0.7** | 1.0 | 1.8 | 3.8 |
| 15 | 21,600 | 0.68 | 0.01 | 0.79 | 0.91 | 1.06 | **1.5** | 2.2 | 3.8 | 8.1 |
| 20 | 28,800 | 0.91 | 0.01 | 1.35 | 1.55 | 1.80 | **2.5** | 3.8 | 6.5 | 13.8 |
| 25 | 36,000 | 1.13 | 0.02 | 2.04 | 2.34 | 2.71 | **3.8** | 5.8 | 9.8 | 20.8 |
| 30 | 43,200 | 1.36 | 0.03 | 2.87 | 3.29 | 3.81 | **5.4** | 8.1 | 13.8 | 29.2 |
| 35 | 50,400 | 1.59 | 0.04 | 3.81 | 4.38 | 5.1 | **7.1** | 10.7 | 18.3 | 38.9 |
| 40 | 57,600 | 1.82 | 0.05 | 4.89 | 5.6 | 6.5 | **9.1** | 13.8 | 23.5 | 49.7 |
| 50 | 72,000 | 2.27 | 0.08 | 7.4 | 8.5 | 9.8 | **13.8** | 20.8 | 35.5 | 75 |
| 60 | 86,400 | 2.72 | 0.12 | 10.3 | 11.8 | 13.7 | **19.2** | 29.1 | 49.6 | 105 |
| 70 | 100,800 | 3.18 | 0.16 | 13.8 | 15.8 | 18.3 | **25.7** | 38.8 | 66 | 140 |
| 80 | 115,200 | 3.63 | 0.20 | 17.6 | 20.2 | 23.4 | **32.8** | 49.6 | 84 | 179 |
| 90 | 129,600 | 4.09 | 0.26 | 21.9 | 25.1 | 29.1 | **40.8** | 62 | 105 | 223 |
| 100 | 144,000 | 4.54 | 0.32 | 26.7 | 30.6 | 35.2 | **49.6** | 75 | 128 | 271 |
| 120 | 172,800 | 5.45 | 0.46 | 37.2 | 42.8 | 49.7 | **70** | 106 | 179 | 380 |
| 140 | 201,600 | 6.35 | 0.63 | 49.6 | 57 | 66 | **92** | 139 | 238 | 510 |
| 160 | 230,400 | 7.26 | 0.82 | 64 | 73 | 84 | **118** | 179 | 306 | 650 |
| 180 | 259,200 | 8.17 | 1.04 | 79 | 91 | 106 | **148** | 223 | 380 | 810 |
| 200 | 288,000 | 9.08 | 1.28 | 96 | 110 | 128 | **178** | 271 | 461 | 980 |
| 220 | 316,800 | 9.99 | 1.55 | 114 | 132 | 153 | **213** | 323 | 550 | 1170 |
| 240 | 345,600 | 10.89 | 1.84 | 134 | 154 | 179 | **251** | 380 | 650 | 1370 |
| 260 | 374,400 | 11.80 | 2.16 | 156 | 179 | 208 | **291** | 440 | 750 | 1590 |
| 280 | 403,200 | 12.71 | 2.51 | 179 | 206 | 238 | **334** | 510 | 860 | 1830 |
| 300 | 432,000 | 13.62 | 2.88 | 204 | 233 | 271 | **380** | 580 | 980 | 2080 |
| 320 | 460,800 | 14.52 | 3.28 | 229 | 263 | 306 | **428** | 650 | 1110 | 2330 |
| 340 | 489,600 | 15.43 | 3.71 | 257 | 294 | 342 | **479** | 720 | 1230 | 2610 |
| 360 | 518,400 | 16.34 | 4.15 | 286 | 328 | 380 | **530** | 800 | 1370 | 2910 |
| 380 | 547,200 | 17.25 | 4.62 | 317 | 361 | 420 | **590** | 890 | 1520 | 3210 |
| 400 | 576,000 | 18.16 | 5.11 | 348 | 399 | 461 | **650** | 980 | 1670 | 3520 |
| 420 | 604,800 | 19.06 | 5.64 | 380 | 436 | 510 | **710** | 1070 | 1830 | 3870 |
| 440 | 633,600 | 19.97 | 6.20 | 414 | 475 | 550 | **770** | 1170 | 1980 | 4220 |
| 460 | 662,400 | 20.88 | 6.78 | 449 | 520 | 600 | **840** | 1270 | 2160 | 4570 |
| 480 | 691,200 | 21.79 | 7.38 | 488 | 560 | 650 | **910** | 1370 | 2330 | 4980 |
| 500 | 720,000 | 22.70 | 8.00 | 530 | 600 | 700 | **980** | 1480 | 2520 | 5400 |
| 550 | 792,000 | 24.96 | 9.70 | 620 | 720 | 830 | **1170** | 1770 | 3010 | 6400 |
| 600 | 864,000 | 27.23 | 11.50 | 740 | 840 | 980 | **1370** | 2070 | 3520 | 7400 |

| Discharge in Gallons. | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Per Minute. | Per 24 Hours. | | | 00 c=140 | 0 c=130 | 4 c=120 | 13 c=100 | 26 c=80 | 45 c=60 | 75 c=40 |
| 20 | 28,800 | 0.51 | 0.00 | 0.33 | 0.38 | 0.44 | **0.62** | 0.9 | 1.6 | 3.4 |
| 25 | 36,000 | 0.64 | 0.01 | 0.50 | 0.58 | 0.67 | **0.94** | 1.4 | 2.4 | 5.1 |
| 30 | 43,200 | 0.77 | 0.01 | 0.70 | 0.81 | 0.94 | **1.32** | 2.0 | 3.4 | 7.2 |
| 35 | 50,400 | 0.89 | 0.01 | 0.94 | 1.07 | 1.24 | **1.74** | 2.6 | 4.5 | 9.6 |
| 40 | 57,600 | 1.02 | 0.02 | 1.20 | 1.38 | 1.59 | **2.23** | 3.4 | 5.8 | 12.2 |
| 50 | 72,000 | 1.28 | 0.03 | 1.82 | 2.08 | 2.41 | **3.39** | 5.1 | 8.8 | 18.5 |
| 60 | 86,400 | 1.53 | 0.04 | 2.53 | 2.91 | 3.38 | **4.72** | 7.2 | 12.2 | 25.9 |
| 70 | 100,800 | 1.79 | 0.05 | 3.38 | 3.88 | 4.50 | **6.3** | 9.5 | 16.3 | 34.4 |
| 80 | 115,200 | 2.04 | 0.06 | 4.32 | 4.97 | 5.8 | **8.1** | 12.2 | 20.8 | 44 |
| 90 | 129,600 | 2.30 | 0.08 | 5.4 | 6.2 | 7.2 | **10.0** | 15.2 | 25.9 | 55 |
| 100 | 144,000 | 2.55 | 0.10 | 6.5 | 7.5 | 8.8 | **12.2** | 18.5 | 31.3 | 66 |
| 120 | 172,800 | 3.06 | 0.15 | 9.2 | 10.5 | 12.2 | **17.1** | 25.8 | 44 | 93 |
| 140 | 201,600 | 3.57 | 0.20 | 12.2 | 14.0 | 16.2 | **22.8** | 34.4 | 59 | 124 |
| 160 | 230,400 | 4.08 | 0.26 | 15.7 | 17.9 | 20.8 | **29.1** | 44 | 75 | 159 |
| 180 | 259,200 | 4.60 | 0.33 | 19.4 | 22.2 | 25.9 | **36.1** | 55 | 93 | 198 |
| 200 | 288,000 | 5.11 | 0.41 | 23.7 | 27.0 | 31.2 | **44** | 66 | 113 | 240 |
| 220 | 316,800 | 5.62 | 0.49 | 28.1 | 32.2 | 37.3 | **52** | 79 | 135 | 287 |
| 240 | 345,600 | 6.13 | 0.58 | 33.0 | 37.9 | 44 | **62** | 93 | 158 | 337 |
| 260 | 374,400 | 6.64 | 0.69 | 38.3 | 44 | 51 | **72** | 108 | 184 | 391 |
| 280 | 403,200 | 7.15 | 0.79 | 44.0 | 50 | 59 | **82** | 124 | 210 | 448 |
| 300 | 432,000 | 7.66 | 0.91 | 50 | 57 | 67 | **93** | 141 | 240 | 510 |
| 320 | 460,800 | 8.17 | 1.04 | 56 | 65 | 75 | **105** | 158 | 271 | 580 |
| 340 | 489,600 | 8.68 | 1.17 | 63 | 72 | 84 | **117** | 178 | 303 | 640 |
| 360 | 518,400 | 9.19 | 1.31 | 70 | 80 | 93 | **131** | 197 | 337 | 710 |
| 400 | 576,000 | 10.21 | 1.62 | 85 | 98 | 113 | **160** | 241 | 410 | 870 |
| 450 | 648,000 | 11.49 | 2.05 | 107 | 122 | 141 | **198** | 299 | 510 | 1080 |
| 500 | 720,000 | 12.77 | 2.53 | 129 | 148 | 172 | **240** | 362 | 620 | 1320 |
| 550 | 792,000 | 14.04 | 3.06 | 153 | 177 | 205 | **287** | 433 | 740 | 1570 |
| 600 | 864,000 | 15.32 | 3.65 | 181 | 207 | 240 | **337** | 510 | 870 | 1840 |
| 650 | 936,000 | 16.59 | 4.28 | 209 | 240 | 279 | **390** | 590 | 1010 | 2130 |
| 700 | 1,008,000 | 17.87 | 4.96 | 240 | 276 | 320 | **449** | 680 | 1160 | 2450 |
| 750 | 1,080,000 | 19.15 | 5.70 | 272 | 312 | 362 | **510** | 770 | 1310 | 2790 |
| 800 | 1,152,000 | 20.42 | 6.48 | 308 | 352 | 410 | **570** | 870 | 1480 | 3120 |
| 850 | 1,224,000 | 21.70 | 7.30 | 343 | 395 | 458 | **640** | 970 | 1650 | 3510 |
| 900 | 1,296,000 | 22.98 | 8.20 | 382 | 439 | 510 | **710** | 1080 | 1840 | 3900 |

# 5-INCH PIPE.

| Discharge in Gallons. Per Minute. | Discharge in Gallons. Per 24 Hours. | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. (00) c=140 | (0) c=130 | (4) c=120 | (14) c=100 | (28) c=80 | (50) c=60 | (87) c=40 |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 43,200 | 0.49 | 0.00 | 0.24 | 0.27 | 0.31 | **0.44** | 0.67 | 1.1 | 2.4 |
| 40 | 57,600 | 0.65 | 0.01 | 0.40 | 0.46 | 0.54 | **0.75** | 1.14 | 1.9 | 4.1 |
| 50 | 72,000 | 0.82 | 0.01 | 0.61 | 0.70 | 0.81 | **1.13** | 1.72 | 2.9 | 6.2 |
| 60 | 86,400 | 0.98 | 0.02 | 0.86 | 0.98 | 1.13 | **1.59** | 2.41 | 4.1 | 8.7 |
| 70 | 100,800 | 1.14 | 0.02 | 1.14 | 1.31 | 1.52 | **2.12** | 3.21 | 5.5 | 11.7 |
| 80 | 115,200 | 1.31 | 0.03 | 1.46 | 1.67 | 1.94 | **2.71** | 4.11 | 7.0 | 14.8 |
| 90 | 129,600 | 1.47 | 0.03 | 1.82 | 2.08 | 2.41 | **3.39** | 5.1 | 8.7 | 18.5 |
| 100 | 144,000 | 1.63 | 0.04 | 2.21 | 2.53 | 2.94 | **4.11** | 6.2 | 10.7 | 22.5 |
| 120 | 172,800 | 1.96 | 0.06 | 3.09 | 3.54 | 4.11 | **5.8** | 8.7 | 14.8 | 31.5 |
| 140 | 201,600 | 2.29 | 0.08 | 4.11 | 4.71 | 5.5 | **7.6** | 11.6 | 19.8 | 41.9 |
| 160 | 230,400 | 2.61 | 0.11 | 5.3 | 6.0 | 7.0 | **9.8** | 14.8 | 25.2 | 54 |
| 180 | 259,200 | 2.94 | 0.13 | 6.6 | 7.5 | 8.7 | **12.2** | 18.4 | 31.4 | 67 |
| 200 | 288,000 | 3.27 | 0.17 | 8.0 | 9.1 | 10.6 | **14.8** | 22.4 | 38.1 | 81 |
| 220 | 316,800 | 3.59 | 0.20 | 9.5 | 10.8 | 12.6 | **17.7** | 26.8 | 45.6 | 96 |
| 240 | 345,600 | 3.92 | 0.24 | 11.2 | 12.8 | 14.8 | **20.8** | 31.4 | 54 | 113 |
| 260 | 374,400 | 4.25 | 0.28 | 12.9 | 14.8 | 17.2 | **24.1** | 36.7 | 62 | 132 |
| 280 | 403,200 | 4.58 | 0.33 | 14.8 | 17.0 | 19.7 | **27.7** | 41.9 | 72 | 152 |
| 300 | 432,000 | 4.90 | 0.37 | 16.8 | 19.4 | 22.5 | **31.4** | 47.7 | 81 | 172 |
| 320 | 460,800 | 5.23 | 0.42 | 19.0 | 21.8 | 25.2 | **35.4** | 54 | 91 | 193 |
| 350 | 504,000 | 5.72 | 0.51 | 22.4 | 25.8 | 29.9 | **41.9** | 63 | 108 | 229 |
| 400 | 576,000 | 6.54 | 0.66 | 28.8 | 32.9 | 38.1 | **54** | 81 | 138 | 292 |
| 450 | 648,000 | 7.35 | 0.84 | 35.8 | 41.0 | 47.5 | **67** | 101 | 172 | 364 |
| 500 | 720.000 | 8.17 | 1.04 | 43.5 | 49.9 | 58 | **81** | 122 | 209 | 442 |
| 550 | 792,000 | 8.99 | 1.26 | 52 | 60 | 69 | **96** | 146 | 249 | 530 |
| 600 | 864,000 | 9.80 | 1.49 | 61 | 70 | 81 | **113** | 172 | 292 | 620 |
| 650 | 936,000 | 10.62 | 1.75 | 71 | 81 | 94 | **132** | 199 | 339 | 720 |
| 700 | 1,008,000 | 11.44 | 2.03 | 81 | 93 | 108 | **151** | 229 | 388 | 820 |
| 750 | 1,080,000 | 12.26 | 2.34 | 92 | 106 | 123 | **172** | 260 | 442 | 940 |
| 800 | 1,152,000 | 13.07 | 2.66 | 104 | 119 | 138 | **194** | 292 | 499 | 1060 |
| 850 | 1,224,000 | 13.89 | 2.99 | 117 | 133 | 154 | **217** | 328 | 560 | 1180 |
| 900 | 1,296,000 | 14.71 | 3.36 | 129 | 148 | 172 | **240** | 362 | 620 | 1320 |
| 950 | 1,368,000 | 15.52 | 3.74 | 143 | 163 | 190 | **267** | 402 | 690 | 1450 |
| 1000 | 1,440,000 | 16.34 | 4.15 | 157 | 180 | 209 | **292** | 443 | 750 | 1600 |
| 1100 | 1,584,000 | 17.97 | 5.00 | 187 | 214 | 249 | **349** | 530 | 900 | 1910 |
| 1200 | 1,728,000 | 19.61 | 5.96 | 220 | 251 | 292 | **409** | 620 | 1480 | 2240 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 $c=140$ | 0 $c=130$ | 4 $c=120$ | 15 $c=100$ | 30 $c=80$ | 55 $c=60$ | 95 $c=40$ |
| 50,000 | 0.0774 | 0.39 | 0.00 | 0.13 | 0.15 | 0.17 | 0.24 | 0.36 | 0.61 | 1.3 |
| 60,000 | 0.0928 | 0.47 | 0.00 | 0.18 | 0.20 | 0.24 | 0.33 | 0.51 | 0.86 | 1.8 |
| 70,000 | 0.1083 | 0.55 | 0.00 | 0.24 | 0.27 | 0.32 | 0.44 | 0.67 | 1.15 | 2.4 |
| 80,000 | 0.1238 | 0.63 | 0.01 | 0.30 | 0.35 | 0.41 | 0.57 | 0.86 | 1.46 | 3.1 |
| 90,000 | 0.1392 | 0.71 | 0.01 | 0.38 | 0.43 | 0.51 | 0.71 | 1.07 | 1.83 | 3.9 |
| 100,000 | 0.1547 | 0.79 | 0.01 | 0.46 | 0.53 | 0.61 | 0.86 | 1.30 | 2.22 | 4.7 |
| 110,000 | 0.1702 | 0.87 | 0.01 | 0.55 | 0.63 | 0.73 | 1.03 | 1.55 | 2.65 | 5.6 |
| 120,000 | 0.1857 | 0.95 | 0.01 | 0.65 | 0.74 | 0.86 | 1.21 | 1.84 | 3.11 | 6.6 |
| 140,000 | 0.2166 | 1.10 | 0.02 | 0.87 | 0.99 | 1.15 | 1.62 | 2.45 | 4.17 | 8.8 |
| 160,000 | 0.2476 | 1.26 | 0.02 | 1.10 | 1.26 | 1.46 | 2.06 | 3.10 | 5.3 | 11.2 |
| 180,000 | 0.2785 | 1.42 | 0.03 | 1.37 | 1.57 | 1.83 | 2.56 | 3.88 | 6.6 | 14.0 |
| 200,000 | 0.3094 | 1.58 | 0.04 | 1.67 | 1.91 | 2.22 | 3.10 | 4.70 | 8.0 | 17.0 |
| 220,000 | 0.3404 | 1.73 | 0.05 | 1.99 | 2.29 | 2.65 | 3.71 | 5.6 | 9.6 | 20.2 |
| 240,000 | 0.3713 | 1.89 | 0.06 | 2.33 | 2.69 | 3.11 | 4.35 | 6.6 | 11.2 | 23.9 |
| 260,000 | 0.4023 | 2.05 | 0.07 | 2.71 | 3.10 | 3.60 | 5.0 | 7.6 | 13.0 | 27.5 |
| 280,000 | 0.4332 | 2.21 | 0.08 | 3.11 | 3.58 | 4.14 | 5.8 | 8.8 | 15.0 | 31.7 |
| 300,000 | 0.4642 | 2.36 | 0.09 | 3.54 | 4.06 | 4.70 | 6.6 | 10.0 | 17.0 | 36.0 |
| 350,000 | 0.541 | 2.76 | 0.12 | 4.70 | 5.4 | 6.3 | 8.8 | 13.3 | 22.5 | 48.0 |
| 400,000 | 0.619 | 3.15 | 0.15 | 6.0 | 6.9 | 8.0 | 11.3 | 17.0 | 29.0 | 62 |
| 450,000 | 0.696 | 3.55 | 0.19 | 7.5 | 8.6 | 10.0 | 14.0 | 21.2 | 36.0 | 76 |
| 500,000 | 0.774 | 3.94 | 0.24 | 9.1 | 10.4 | 12.1 | 16.9 | 25.6 | 43.8 | 92 |
| 550,000 | 0.851 | 4.33 | 0.29 | 10.8 | 12.4 | 14.4 | 20.1 | 30.5 | 52 | 110 |
| 600,000 | 0.928 | 4.73 | 0.35 | 12.8 | 14.6 | 17.0 | 23.8 | 36.0 | 61 | 130 |
| 650,000 | 1.006 | 5.12 | 0.41 | 14.7 | 16.9 | 19.6 | 27.5 | 41.6 | 71 | 150 |
| 700,000 | 1.083 | 5.52 | 0.47 | 17.0 | 19.5 | 22.6 | 31.6 | 48.0 | 82 | 173 |
| 800,000 | 1.238 | 6.30 | 0.62 | 21.6 | 24.9 | 28.9 | 40.4 | 61 | 104 | 221 |
| 900,000 | 1.392 | 7.09 | 0.78 | 26.9 | 30.9 | 35.8 | 50 | 76 | 129 | 274 |
| 1,000,000 | 1.547 | 7.88 | 0.97 | 32.9 | 37.8 | 43.8 | 61 | 93 | 158 | 334 |
| 1,100,000 | 1.702 | 8.67 | 1.17 | 39.2 | 45.1 | 52 | 73 | 111 | 189 | 400 |
| 1,200,000 | 1.857 | 9.46 | 1.39 | 46.0 | 53 | 61 | 86 | 130 | 220 | 470 |
| 1,400,000 | 2.166 | 11.03 | 1.89 | 61 | 70 | 82 | 114 | 173 | 295 | 620 |
| 1,600,000 | 2.476 | 12.61 | 2.46 | 78 | 90 | 104 | 146 | 221 | 377 | 800 |
| 1,800,000 | 2.785 | 14.18 | 3.12 | 98 | 112 | 130 | 182 | 275 | 470 | 990 |
| 2,000,000 | 3.094 | 15.76 | 3.85 | 119 | 137 | 159 | 222 | 337 | 570 | 1210 |
| 2,200,000 | 3.404 | 17.34 | 4.65 | 141 | 162 | 188 | 263 | 400 | 680 | 1440 |

# 8-INCH PIPE.

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 c=140 | 0 c=130 | 5 c=120 | 10 c=110 | 16 c=100 | 33 c=80 | 62 c=60 |
| 200,000 | 0.3094 | 0.89 | 0.01 | 0.41 | 0.47 | 0.55 | 0.64 | **0.77** | 1.16 | 1.98 |
| 220,000 | 0.3404 | 0.98 | 0.01 | 0.49 | 0.56 | 0.65 | 0.77 | **0.92** | 1.38 | 2.35 |
| 240,000 | 0.3713 | 1.06 | 0.02 | 0.58 | 0.66 | 0.77 | 0.90 | **1.07** | 1.62 | 2.78 |
| 260,000 | 0.4023 | 1.15 | 0.02 | 0.67 | 0.77 | 0.89 | 1.05 | **1.25** | 1.89 | 3.21 |
| 280,000 | 0.4332 | 1.24 | 0.02 | 0.77 | 0.88 | 1.02 | 1.20 | **1.43** | 2.16 | 3.69 |
| 300,000 | 0.4642 | 1.33 | 0.03 | 0.87 | 1.00 | 1.16 | 1.36 | **1.62** | 2.46 | 4.19 |
| 320,000 | 0.4951 | 1.42 | 0.03 | 0.98 | 1.13 | 1.31 | 1.54 | **1.84** | 2.78 | 4.72 |
| 340,000 | 0.526 | 1.51 | 0.04 | 1.10 | 1.26 | 1.46 | 1.72 | **2.05** | 3.10 | 5.3 |
| 360,000 | 0.557 | 1.60 | 0.04 | 1.22 | 1.40 | 1.62 | 1.91 | **2.28** | 3.44 | 5.9 |
| 380,000 | 0.588 | 1.68 | 0.04 | 1.35 | 1.55 | 1.80 | 2.11 | **2.51** | 3.80 | 6.5 |
| 400,000 | 0.619 | 1.77 | 0.05 | 1.48 | 1.70 | 1.97 | 2.32 | **2.76** | 4.20 | 7.1 |
| 450,000 | 0.696 | 1.99 | 0.06 | 1.85 | 2.11 | 2.45 | 2.89 | **3.43** | 5.2 | 8.9 |
| 500,000 | 0.774 | 2.22 | 0.08 | 2.25 | 2.58 | 2.99 | 3.50 | **4.18** | 6.3 | 10.7 |
| 550,000 | 0.851 | 2.44 | 0.09 | 2.68 | 3.07 | 3.55 | 4.19 | **5.0** | 7.6 | 12.9 |
| 600,000 | 0.928 | 2.66 | 0.11 | 3.14 | 3.61 | 4.19 | 4.91 | **5.9** | 8.9 | 15.1 |
| 650,000 | 1.006 | 2.88 | 0.13 | 3.64 | 4.18 | 4.84 | 5.7 | **6.8** | 10.3 | 17.5 |
| 700,000 | 1.083 | 3.10 | 0.15 | 4.19 | 4.80 | 5.6 | 6.5 | **7.8** | 11.8 | 20.0 |
| 750,000 | 1.160 | 3.32 | 0.17 | 4.73 | 5.4 | 6.3 | 7.4 | **8.8** | 13.3 | 22.8 |
| 800,000 | 1.238 | 3.55 | 0.20 | 5.3 | 6.1 | 7.1 | 8.4 | **9.9** | 15.1 | 25.7 |
| 900,000 | 1.392 | 3.99 | 0.25 | 6.7 | 7.6 | 8.9 | 10.4 | **12.4** | 18.8 | 32.0 |
| 1,000,000 | 1.547 | 4.43 | 0.30 | 8.1 | 9.3 | 10.8 | 12.7 | **15.1** | 23.0 | 39.0 |
| 1,100,000 | 1.702 | 4.88 | 0.37 | 9.6 | 11.1 | 12.8 | 15.1 | **18.0** | 27.2 | 46.2 |
| 1,200,000 | 1.857 | 5.37 | 0.44 | 11.3 | 13.0 | 15.1 | 17.7 | **21.1** | 32.0 | 54 |
| 1,300,000 | 2.011 | 5.76 | 0.52 | 13.1 | 15.1 | 17.5 | 20.5 | **24.5** | 37.0 | 63 |
| 1,400,000 | 2.166 | 6.20 | 0.60 | 15.1 | 17.3 | 20.0 | 23.5 | **28.1** | 42.5 | 72 |
| 1,500,000 | 2.321 | 6.65 | 0.69 | 17.0 | 19.5 | 22.6 | 26.7 | **31.8** | 48 | 82 |
| 1,600,000 | 2.476 | 7.09 | 0.78 | 19.2 | 22.0 | 25.5 | 30.0 | **35.8** | 54 | 93 |
| 1,800,000 | 2.785 | 7.98 | 0.99 | 23.8 | 27.2 | 31.6 | 37.1 | **44.2** | 67 | 114 |
| 2,000,000 | 3.094 | 8.86 | 1.22 | 29.0 | 33.3 | 38.7 | 45.4 | **54** | 82 | 140 |
| 2,200,000 | 3.404 | 9.75 | 1.47 | 34.9 | 40.0 | 46.2 | 54 | **65** | 98 | 167 |
| 2,400,000 | 3.713 | 10.64 | 1.76 | 41.0 | 47 | 55 | 64 | **77** | 116 | 198 |
| 2,600,000 | 4.023 | 11.52 | 2.06 | 47.5 | 55 | 63 | 74 | **89** | 134 | 229 |
| 2,800,000 | 4.332 | 12.41 | 2.39 | 55 | 62 | 73 | 85 | **102** | 153 | 261 |
| 3,000,000 | 4.642 | 13.30 | 2.74 | 62 | 71 | 83 | 97 | **116** | 175 | 300 |
| 3,200,000 | 4.951 | 14.18 | 3.12 | 70 | 80 | 93 | 109 | **130** | 197 | 336 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 $c=140$ | 0 $c=130$ | 5 $c=120$ | 10 $c=110$ | 17 $c=100$ | 35 $c=80$ | 68 $c=60$ |
| 300,000 | 0.464 | 0.85 | 0.01 | 0.29 | 0.34 | 0.39 | 0.46 | **0.55** | 0.83 | 1.41 |
| 320,000 | 0.495 | 0.91 | 0.01 | 0.33 | 0.38 | 0.44 | 0.52 | **0.62** | 0.93 | 1.59 |
| 340,000 | 0.526 | 0.96 | 0.01 | 0.37 | 0.42 | 0.49 | 0.58 | **0.69** | 1.04 | 1.78 |
| 360,000 | 0.557 | 1.02 | 0.02 | 0.41 | 0.47 | 0.55 | 0.64 | **0.77** | 1.16 | 1.98 |
| 380,000 | 0.588 | 1.08 | 0.02 | 0.45 | 0.52 | 0.60 | 0.71 | **0.85** | 1.28 | 2.19 |
| 400,000 | 0.619 | 1.13 | 0.02 | 0.50 | 0.57 | 0.66 | 0.78 | **0.93** | 1.40 | 2.40 |
| 450,000 | 0.696 | 1.28 | 0.03 | 0.62 | 0.71 | 0.83 | 0.97 | **1.16** | 1.75 | 3.00 |
| 500,000 | 0.774 | 1.42 | 0.03 | 0.76 | 0.87 | 1.01 | 1.18 | **1.41** | 2.13 | 3.63 |
| 550,000 | 0.851 | 1.56 | 0.04 | 0.90 | 1.03 | 1.20 | 1.41 | **1.68** | 2.55 | 4.34 |
| 600,000 | 0.928 | 1.70 | 0.04 | 1.06 | 1.21 | 1.41 | 1.65 | **1.97** | 3.00 | 5.1 |
| 650,000 | 1.006 | 1.84 | 0.05 | 1.23 | 1.41 | 1.64 | 1.92 | **2.29** | 3.46 | 5.9 |
| 700,000 | 1.083 | 1.99 | 0.06 | 1.41 | 1.62 | 1.88 | 2.21 | **2.64** | 4.00 | 6.8 |
| 750,000 | 1.160 | 2.13 | 0.07 | 1.60 | 1.84 | 2.14 | 2.50 | **3.00** | 4.52 | 7.7 |
| 800,000 | 1.238 | 2.27 | 0.08 | 1.81 | 2.08 | 2.41 | 2.83 | **3.38** | 5.1 | 8.7 |
| 900,000 | 1.392 | 2.55 | 0.10 | 2.24 | 2.58 | 3.00 | 3.50 | **4.18** | 6.3 | 10.8 |
| 1,000,000 | 1.547 | 2.84 | 0.12 | 2.73 | 3.13 | 3.63 | 4.27 | **5.1** | 7.7 | 13.1 |
| 1,100,000 | 1.702 | 3.12 | 0.15 | 3.25 | 3.72 | 4.32 | 5.1 | **6.1** | 9.2 | 15.5 |
| 1,200,000 | 1.857 | 3.40 | 0.18 | 3.82 | 4.40 | 5.1 | 6.0 | **7.1** | 10.8 | 18.4 |
| 1,300,000 | 2.011 | 3.69 | 0.21 | 4.44 | 5.1 | 5.9 | 6.9 | **8.3** | 12.5 | 21.4 |
| 1,400,000 | 2.166 | 3.97 | 0.24 | 5.1 | 5.8 | 6.8 | 8.0 | **9.5** | 14.4 | 24.5 |
| 1,500,000 | 2.321 | 4.26 | 0.28 | 5.8 | 6.7 | 7.7 | 9.0 | **10.8** | 16.3 | 27.9 |
| 1,600,000 | 2.476 | 4.54 | 0.32 | 6.5 | 7.5 | 8.7 | 10.2 | **12.2** | 18.5 | 31.4 |
| 1,800,000 | 2.785 | 5.11 | 0.41 | 8.1 | 9.3 | 10.8 | 12.7 | **15.1** | 22.9 | 39.0 |
| 2,000,000 | 3.094 | 5.67 | 0.50 | 9.9 | 11.3 | 13.1 | 15.4 | **18.4** | 27.8 | 47.2 |
| 2,200,000 | 3.404 | 6.24 | 0.60 | 11.7 | 13.4 | 15.6 | 18.3 | **21.8** | 33.0 | 56 |
| 2,400,000 | 3.713 | 6.81 | 0.72 | 13.7 | 15.7 | 18.3 | 21.4 | **25.5** | 38.7 | 66 |
| 2,600,000 | 4.023 | 7.38 | 0.84 | 16.0 | 18.4 | 21.3 | 25.0 | **29.9** | 45.0 | 77 |
| 2,800,000 | 4.332 | 7.94 | 0.98 | 18.3 | 21.0 | 24.3 | 28.6 | **34.0** | 51 | 88 |
| 3,000,000 | 4.642 | 8.51 | 1.12 | 20.8 | 23.8 | 27.6 | 32.5 | **38.6** | 59 | 100 |
| 3,200,000 | 4.951 | 9.08 | 1.28 | 23.5 | 27.0 | 31.2 | 36.8 | **43.8** | 66 | 113 |
| 3,400,000 | 5.26 | 9.65 | 1.44 | 26.3 | 30.2 | 35.0 | 41.2 | **49** | 74 | 127 |
| 3,600,000 | 5.57 | 10.21 | 1.62 | 29.2 | 33.5 | 38.9 | 45.5 | **54** | 82 | 140 |
| 3,800,000 | 5.88 | 10.78 | 1.80 | 32.5 | 37.2 | 43.1 | 51 | **60** | 92 | 156 |
| 4,000,000 | 6.19 | 11.35 | 2.00 | 35.5 | 40.8 | 47.3 | 56 | **66** | 100 | 171 |
| 4,500,000 | 6.96 | 12.77 | 2.52 | 44.3 | 51 | 59 | 69 | **83** | 125 | 213 |

| Discharge in: Gallons per 24 Hours. | Discharge in: Cubic Feet per Second. | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. (00) c=140 | (0) c=130 | (5) c=120 | (10) c=110 | (17) c=100 | (26) c=90 | (37) c=80 |
|---|---|---|---|---|---|---|---|---|---|---|
| 100,000 | 0.155 | 0.20 | 0.00 | 0.02 | 0.02 | 0.02 | 0.02 | **0.03** | 0.04 | 0.04 |
| 200,000 | 0.309 | 0.39 | 0.00 | 0.06 | 0.07 | 0.08 | 0.09 | **0.11** | 0.13 | 0.16 |
| 300,000 | 0.464 | 0.59 | 0.01 | 0.12 | 0.14 | 0.16 | 0.19 | **0.22** | 0.27 | 0.34 |
| 400,000 | 0.619 | 0.79 | 0.01 | 0.20 | 0.24 | 0.27 | 0.32 | **0.38** | 0.47 | 0.58 |
| 500,000 | 0.774 | 0.99 | 0.02 | 0.31 | 0.36 | 0.41 | 0.48 | **0.58** | 0.71 | 0.88 |
| 600,000 | 0.928 | 1.18 | 0.02 | 0.44 | 0.50 | 0.58 | 0.68 | **0.81** | 0.99 | 1.23 |
| 700,000 | 1.083 | 1.38 | 0.03 | 0.58 | 0.66 | 0.77 | 0.91 | **1.08** | 1.32 | 1.64 |
| 800,000 | 1.238 | 1.58 | 0.04 | 0.74 | 0.85 | 0.99 | 1.15 | **1.38** | 1.68 | 2.09 |
| 900,000 | 1.392 | 1.77 | 0.05 | 0.92 | 1.06 | 1.23 | 1.45 | **1.72** | 2.10 | 2.61 |
| 1,000,000 | 1.547 | 1.97 | 0.06 | 1.12 | 1.29 | 1.50 | 1.76 | **2.10** | 2.57 | 3.18 |
| 1,100,000 | 1.702 | 2.17 | 0.07 | 1.34 | 1.54 | 1.79 | 2.10 | **2.50** | 3.04 | 3.79 |
| 1,200,000 | 1.857 | 2.36 | 0.09 | 1.58 | 1.81 | 2.10 | 2.47 | **2.94** | 3.58 | 4.45 |
| 1,300,000 | 2.011 | 2.56 | 0.10 | 1.83 | 2.10 | 2.43 | 2.85 | **3.40** | 4.14 | 5.2 |
| 1 400,000 | 2.166 | 2.76 | 0.12 | 2.10 | 2.40 | 2.79 | 3.26 | **3.90** | 4.76 | 5.9 |
| 1,500,000 | 2.321 | 2.96 | 0.14 | 2.39 | 2.73 | 3.17 | 3.71 | **4.43** | 5.4 | 6.7 |
| 1,600,000 | 2.476 | 3.15 | 0.15 | 2.69 | 3.09 | 3.58 | 4.20 | **5.0** | 6.1 | 7.6 |
| 1,700,000 | 2.630 | 3.35 | 0.17 | 3.00 | 3.45 | 4.00 | 4.69 | **5.6** | 6.8 | 8.5 |
| 1,800,000 | 2.785 | 3.55 | 0.20 | 3.33 | 3.82 | 4.43 | 5.2 | **6.2** | 7.6 | 9.4 |
| 1,900,000 | 2.940 | 3.74 | 0.22 | 3.70 | 4.24 | 4.92 | 5.8 | **6.9** | 8.4 | 10.4 |
| 2,000,000 | 3.094 | 3.94 | 0.24 | 4.06 | 4.65 | 5.4 | 6.4 | **7.6** | 9.2 | 11.5 |
| 2,200,000 | 3.404 | 4.33 | 0.29 | 4.85 | 5.6 | 6.5 | 7.6 | **9.0** | 10.9 | 13.7 |
| 2 400,000 | 3.713 | 4.73 | 0.35 | 5.7 | 6.5 | 7.6 | 8.9 | **10.5** | 12.8 | 16.0 |
| 2,600,000 | 4.023 | 5.12 | 0.41 | 6.6 | 7.6 | 8.8 | 10.3 | **12.3** | 15.0 | 18.6 |
| 2,800,000 | 4.332 | 5.52 | 0.47 | 7.6 | 8.7 | 10.1 | 11.9 | **14.1** | 17.2 | 21.5 |
| 3,000,000 | 4.642 | 5.91 | 0.54 | 8.6 | 9.9 | 11.5 | 13.5 | **16.0** | 19.4 | 24.3 |
| 3,500,000 | 5.41 | 6.89 | 0.74 | 11.4 | 13.2 | 15.3 | 17.9 | **21.3** | 26.0 | 32.3 |
| 4,000,000 | 6.19 | 7.88 | 0.96 | 14.5 | 16.6 | 19.3 | 22.6 | **27.0** | 33.2 | 41.0 |
| 4,500,000 | 6.96 | 8.87 | 1.22 | 18.0 | 20.6 | 24.0 | 28.2 | **33.6** | 41.2 | 51 |
| 5,000,000 | 7.74 | 9.85 | 1.50 | 22.0 | 25.1 | 29.2 | 34.3 | **41.0** | 50.0 | 62 |
| 5,500,000 | 8.51 | 10.84 | 1.82 | 26.5 | 30.3 | 35.1 | 41.4 | **49.4** | 60 | 75 |
| 6,000,000 | 9.28 | 11.82 | 2.17 | 31.1 | 35.7 | 41.4 | 48.8 | **58** | 70 | 88 |
| 7,000,000 | 10.83 | 13.79 | 2.96 | 41.2 | 47.2 | 55 | 65 | **77** | 94 | 116 |
| 8,000,000 | 12.38 | 15.76 | 3.86 | 53 | 61 | 71 | 83 | **99** | 121 | 150 |
| 9,000,000 | 13.92 | 17.73 | 4.89 | 66 | 75 | 87 | 103 | **122** | 148 | 185 |
| 10,000,000 | 15.47 | 19.70 | 6.03 | 81 | 93 | 107 | 126 | **150** | 183 | 228 |

| Discharge in: Gallons per 24 Hours | Discharge in: Cubic Feet per Second | Velocity in Feet per Second | Velocity Head, Feet | Loss of Head in Feet per 1000 feet of length. (00) c=140 | (0) c=130 | (5) c=120 | (10) c=110 | (17) c=100 | (26) c=90 | (37) c=80 |
|---|---|---|---|---|---|---|---|---|---|---|
| 100,000 | 0.155 | 0.15 | 0.00 | 0.008 | 0.009 | 0.010 | 0.012 | **0.014** | 0.017 | 0.021 |
| 200,000 | 0.309 | 0.29 | 0.00 | 0.027 | 0.031 | 0.036 | 0.042 | **0.050** | 0.062 | 0.076 |
| 300,000 | 0.464 | 0.43 | 0.00 | 0.057 | 0.066 | 0.076 | 0.089 | **0.107** | 0.130 | 0.161 |
| 400,000 | 0.619 | 0.58 | 0.01 | 0.098 | 0.112 | 0.129 | 0.153 | **0.182** | 0.222 | 0.278 |
| 500,000 | 0.774 | 0.72 | 0.01 | 0.147 | 0.169 | 0.197 | 0.231 | **0.275** | 0.335 | 0.416 |
| 600,000 | 0.928 | 0.87 | 0.01 | 0.207 | 0.238 | 0.275 | 0.324 | **0.388** | 0.469 | 0.58 |
| 700,000 | 1.083 | 1.01 | 0.02 | 0.277 | 0.317 | 0.367 | 0.431 | **0.52** | 0.63 | 0.78 |
| 800,000 | 1.238 | 1.16 | 0.02 | 0.351 | 0.406 | 0.470 | 0.55 | **0.66** | 0.80 | 1.00 |
| 900,000 | 1.392 | 1.30 | 0.03 | 0.440 | 0.50 | 0.58 | 0.68 | **0.82** | 1.00 | 1.23 |
| 1,000,000 | 1.547 | 1.45 | 0.03 | 0.53 | 0.61 | 0.71 | 0.83 | **1.00** | 1.21 | 1.50 |
| 1,100,000 | 1.702 | 1.59 | 0.04 | 0.63 | 0.73 | 0.84 | 1.00 | **1.18** | 1.44 | 1.79 |
| 1,200,000 | 1.857 | 1.73 | 0.05 | 0.74 | 0.86 | 0.99 | 1.17 | **1.38** | 1.70 | 2.09 |
| 1,300,000 | 2.011 | 1.88 | 0.05 | 0.86 | 0.99 | 1.14 | 1.35 | **1.62** | 1.97 | 2.45 |
| 1,400,000 | 2.166 | 2.02 | 0.06 | 0.99 | 1.14 | 1.32 | 1.54 | **1.85** | 2.25 | 2.79 |
| 1,500,000 | 2.321 | 2.17 | 0.07 | 1.13 | 1.28 | 1.50 | 1.75 | **2.10** | 2.57 | 3.18 |
| 1,600,000 | 2.476 | 2.31 | 0.08 | 1.27 | 1.46 | 1.69 | 1.98 | **2.37** | 2.88 | 3.58 |
| 1,700,000 | 2.630 | 2.46 | 0.09 | 1.42 | 1.63 | 1.88 | 2.22 | **2.65** | 3.22 | 4.00 |
| 1,800,000 | 2.785 | 2.60 | 0.10 | 1.58 | 1.82 | 2.10 | 2.46 | **2.93** | 3.59 | 4.45 |
| 1,900,000 | 2.940 | 2.75 | 0.12 | 1.74 | 1.99 | 2.31 | 2.72 | **3.24** | 3.93 | 4.89 |
| 2,000,000 | 3.094 | 2.90 | 0.13 | 1.92 | 2.20 | 2.54 | 2.99 | **3.57** | 4.37 | 5.4 |
| 2,200,000 | 3.404 | 3.18 | 0.16 | 2.33 | 2.64 | 3.05 | 3.60 | **4.28** | 5.2 | 6.5 |
| 2,400,000 | 3.713 | 3.48 | 0.19 | 2.69 | 3.08 | 3.56 | 4.19 | **5.0** | 6.1 | 7.6 |
| 2,600,000 | 4.023 | 3.76 | 0.22 | 3.12 | 3.58 | 4.15 | 4.89 | **5.8** | 7.1 | 8.8 |
| 2,800,000 | 4.332 | 4.05 | 0.25 | 3.58 | 4.12 | 4.78 | 5.3 | **6.7** | 8.2 | 10.2 |
| 3,000,000 | 4.642 | 4.35 | 0.29 | 4.07 | 4.65 | 5.4 | 6.4 | **7.6** | 9.2 | 11.4 |
| 3,500,000 | 5.41 | 5.07 | 0.40 | 5.4 | 6.2 | 7.2 | 8.4 | **10.1** | 12.2 | 15.3 |
| 4,000,000 | 6.19 | 5.79 | 0.52 | 6.9 | 8.0 | 9.2 | 10.8 | **12.9** | 15.7 | 19.5 |
| 4,500,000 | 6.96 | 6.51 | 0.66 | 8.6 | 9.9 | 11.5 | 13.5 | **16.1** | 19.6 | 24.2 |
| 5,000,000 | 7.74 | 7.24 | 0.81 | 10.4 | 12.0 | 13.9 | 16.4 | **19.5** | 23.9 | 29.6 |
| 5,500,000 | 8.51 | 7.96 | 0.98 | 12.5 | 14.3 | 16.6 | 19.6 | **23.2** | 28.2 | 35.1 |
| 6,000,000 | 9.28 | 8.68 | 1.17 | 14.7 | 16.8 | 19.5 | 22.9 | **27.3** | 33.2 | 41.5 |
| 7,000,000 | 10.83 | 10.12 | 1.59 | 19.5 | 22.3 | 25.9 | 30.5 | **36.5** | 44.1 | 55 |
| 8,000,000 | 12.38 | 11.58 | 2.08 | 24.9 | 28.7 | 33.5 | 38.9 | **46.4** | 57 | 70 |
| 9,000,000 | 13.92 | 13.02 | 2.64 | 31.1 | 35.9 | 41.6 | 48.9 | **58** | 70 | 87 |
| 10,000,000 | 15.47 | 14.48 | 3.27 | 37.8 | 43.5 | 50 | 59 | **70** | 85 | 106 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 $c=140$ | 0 $c=130$ | 5 $c=120$ | 11 $c=110$ | 18 $c=100$ | 27 $c=90$ | 39 $c=80$ |
| 200.000 | 0.309 | 0.22 | 0.00 | 0.014 | 0.016 | 0.019 | 0.022 | **0.026** | 0.03 | 0.04 |
| 400,000 | 0.619 | 0.44 | 0.00 | 0.051 | 0.058 | 0.068 | 0.080 | **0.095** | 0.12 | 0.14 |
| 600,000 | 0.928 | 0.66 | 0.01 | 0.108 | 0.124 | 0.143 | 0.169 | **0.201** | 0.24 | 0.30 |
| 800,000 | 1.238 | 0.89 | 0.01 | 0.183 | 0.210 | 0.242 | 0.287 | **0.340** | 0.41 | 0.52 |
| 1,000,000 | 1.547 | 1.11 | 0.02 | 0.278 | 0.319 | 0.369 | 0.434 | **0.52** | 0.63 | 0.78 |
| 1,200,000 | 1.857 | 1.33 | 0.03 | 0.389 | 0.446 | 0.52 | 0.61 | **0.72** | 0.88 | 1.09 |
| 1,400,000 | 2.166 | 1.55 | 0.04 | 0.52 | 0.60 | 0.69 | 0.81 | **0.96** | 1.18 | 1.47 |
| 1,600,000 | 2.476 | 1.77 | 0.05 | 0.66 | 0.76 | 0.88 | 1.03 | **1.23** | 1.50 | 1.87 |
| 1,800,000 | 2.785 | 1.99 | 0.06 | 0.82 | 0.95 | 1.09 | 1.28 | **1.53** | 1.87 | 2.32 |
| 2,000,000 | 3.094 | 2.22 | 0.08 | 1.00 | 1.15 | 1.33 | 1.57 | **1.87** | 2.28 | 2.82 |
| 2,200,000 | 3.404 | 2.44 | 0.09 | 1.19 | 1.37 | 1.59 | 1.87 | **2.22** | 2.71 | 3.35 |
| 2,400,000 | 3.713 | 2.66 | 0.11 | 1.41 | 1.62 | 1.87 | 2.19 | **2.62** | 3.19 | 3.98 |
| 2,600,000 | 4.023 | 2.88 | 0.13 | 1.63 | 1.87 | 2.17 | 2.55 | **3.03** | 3.69 | 4.60 |
| 2,800,000 | 4.332 | 3.10 | 0.15 | 1.87 | 2.15 | 2.49 | 2.92 | **3.49** | 4.24 | 5.3 |
| 3,000,000 | 4.642 | 3.32 | 0.17 | 2.12 | 2.43 | 2.83 | 3.32 | **3.98** | 4.81 | 6.0 |
| 3,200,000 | 4.951 | 3.55 | 0.19 | 2.39 | 2.75 | 3.19 | 3.75 | **4.46** | 5.4 | 6.8 |
| 3,400,000 | 5.26 | 3.77 | 0.22 | 2.69 | 3.08 | 3.57 | 4.19 | **4.99** | 6.1 | 7.6 |
| 3,600,000 | 5.57 | 3.99 | 0.25 | 2.98 | 3.42 | 3.97 | 4.65 | **5.6** | 6.8 | 8.4 |
| 3,800,000 | 5.88 | 4.21 | 0.28 | 3.29 | 3.78 | 4.38 | 5.1 | **6.2** | 7.4 | 9.3 |
| 4,000,000 | 6.19 | 4.43 | 0.31 | 3.61 | 4.15 | 4.80 | 5.6 | **6.8** | 8.2 | 10.2 |
| 4,500,000 | 6.96 | 4.99 | 0.39 | 4.50 | 5.2 | 6.0 | 7.0 | **8.4** | 10.2 | 12.7 |
| 5,000,000 | 7.74 | 5.54 | 0.48 | 5.5 | 6.3 | 7.3 | 8.6 | **10.2** | 12.4 | 15.4 |
| 5,500,000 | 8.51 | 6.09 | 0.58 | 6.6 | 7.5 | 8.7 | 10.2 | **12.2** | 14.8 | 18.4 |
| 6,000,000 | 9.28 | 6.65 | 0.69 | 7.7 | 8.8 | 10.2 | 12.0 | **14.3** | 17.4 | 21.7 |
| 6,500,000 | 10.06 | 7.20 | 0.81 | 8.9 | 10.2 | 11.8 | 13.9 | **16.6** | 20.2 | 25.1 |
| 7,000,000 | 10.83 | 7.76 | 0.93 | 10.2 | 11.7 | 13.6 | 15.9 | **19.0** | 23.2 | 28.8 |
| 7,500,000 | 11.60 | 8.31 | 1.08 | 11.6 | 13.3 | 15.4 | 18.1 | **21.7** | 26.2 | 32.8 |
| 8,000,000 | 12.38 | 8.86 | 1.22 | 13.1 | 14.9 | 17.4 | 20.3 | **24.2** | 29.6 | 36.9 |
| 9,000,000 | 13.92 | 9.97 | 1.54 | 16.3 | 18.6 | 21.7 | 25.2 | **30.2** | 36.9 | 45.9 |
| 10,000,000 | 15.47 | 11.08 | 1.90 | 19.8 | 22.6 | 26.2 | 30.9 | **36.8** | 45.0 | 56 |
| 11,000,000 | 17.02 | 12.19 | 2.30 | 23.6 | 27.0 | 31.2 | 36.9 | **44.0** | 54 | 66 |
| 12,000,000 | 18.57 | 13.30 | 2.74 | 27.8 | 31.8 | 36.9 | 43.2 | **52** | 63 | 78 |
| 13,000,000 | 20.11 | 14.40 | 3.22 | 32.1 | 36.8 | 42.8 | 50 | **60** | 73 | 90 |
| 14,000,000 | 21.66 | 15.51 | 3.73 | 36.9 | 42.2 | 49.0 | 58 | **68** | 83 | 103 |
| 15,000,000 | 23.21 | 16.62 | 4.29 | 41.9 | 48.0 | 56 | 66 | **78** | 95 | 117 |

| Discharge in | | Velocity in Feet per Second | Velocity Head, Feet | Loss of Head in Feet per 1000 feet of length | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gallons per 24 Hours | Cubic Feet per Second | | | 00 $c=140$ | 0 $c=130$ | 5 $c=120$ | 11 $c=110$ | 18 $c=100$ | 27 $c=90$ | 40 $c=80$ |
| 200,000 | 0.309 | 0.17 | 0.00 | 0.008 | 0.009 | 0.010 | 0.012 | **0.015** | 0.018 | 0.022 |
| 400,000 | 0.619 | 0.35 | 0.00 | 0.029 | 0.033 | 0.038 | 0.044 | **0.053** | 0.065 | 0.081 |
| 600,000 | 0.928 | 0.52 | 0.00 | 0.061 | 0.069 | 0.079 | 0.094 | **0.113** | 0.137 | 0.171 |
| 800,000 | 1.238 | 0.70 | 0.01 | 0.103 | 0.118 | 0.137 | 0.160 | **0.193** | 0.234 | 0.292 |
| 1,000,000 | 1.547 | 0.88 | 0.01 | 0.156 | 0.179 | 0.208 | 0.244 | **0.291** | 0.355 | 0.441 |
| 1,200,000 | 1.857 | 1.05 | 0.02 | 0.218 | 0.251 | 0.291 | 0.341 | **0.409** | 0.495 | 0.62 |
| 1,400,000 | 2.166 | 1.22 | 0.02 | 0.290 | 0.333 | 0.388 | 0.454 | **0.54** | 0.66 | 0.82 |
| 1,600,000 | 2.476 | 1.40 | 0.03 | 0.374 | 0.430 | 0.495 | 0.58 | **0.69** | 0.85 | 1.06 |
| 1,800,000 | 2.785 | 1.57 | 0.04 | 0.461 | 0.53 | 0.62 | 0.72 | **0.86** | 1.05 | 1.31 |
| 2,000,000 | 3.094 | 1.75 | 0.05 | 0.56 | 0.65 | 0.75 | 0.88 | **1.05** | 1.27 | 1.58 |
| 2,200,000 | 3.404 | 1.93 | 0.06 | 0.67 | 0.77 | 0.89 | 1.05 | **1.25** | 1.52 | 1.89 |
| 2,400,000 | 3.713 | 2.10 | 0.07 | 0.79 | 0.90 | 1.05 | 1.24 | **1.47** | 1.79 | 2.23 |
| 2,600,000 | 4.023 | 2.28 | 0.08 | 0.92 | 1.06 | 1.22 | 1.43 | **1.71** | 2.08 | 2.60 |
| 2,800,000 | 4.332 | 2.45 | 0.09 | 1.05 | 1.21 | 1.39 | 1.64 | **1.96** | 2.38 | 2.97 |
| 3,000,000 | 4.642 | 2.63 | 0.10 | 1.19 | 1.37 | 1.58 | 1.86 | **2.23** | 2.70 | 3.38 |
| 3,500,000 | 5.41 | 3.07 | 0.15 | 1.58 | 1.83 | 2.12 | 2.48 | **2.96** | 3.60 | 4.48 |
| 4,000,000 | 6.19 | 3.50 | 0.19 | 2.02 | 2.34 | 2.70 | 3.16 | **3.79** | 4.60 | 5.7 |
| 4,500,000 | 6.96 | 3.94 | 0.24 | 2.53 | 2.92 | 3.37 | 3.93 | **4.71** | 5.7 | 7.1 |
| 5,000,000 | 7.74 | 4.38 | 0.30 | 3.07 | 3.53 | 4.09 | 4.80 | **5.7** | 7.0 | 8.7 |
| 5,500,000 | 8.51 | 4.83 | 0.36 | 3.68 | 4.20 | 4.85 | 5.8 | **6.8** | 8.3 | 10.3 |
| 6,000,000 | 9.28 | 5.25 | 0.43 | 4.31 | 4.95 | 5.4 | 6.7 | **8.0** | 9.8 | 12.2 |
| 6,500,000 | 10.06 | 5.70 | 0.50 | 4.98 | 5.7 | 6.6 | 7.8 | **9.3** | 11.3 | 14.1 |
| 7,000,000 | 10.83 | 6.13 | 0.58 | 5.8 | 6.6 | 7.6 | 8.9 | **10.7** | 13.0 | 16.2 |
| 7,500,000 | 11.60 | 6.57 | 0.67 | 6.5 | 7.5 | 8.8 | 10.1 | **12.2** | 14.7 | 18.4 |
| 8,000,000 | 12.38 | 7.01 | 0.76 | 7.4 | 8.4 | 9.7 | 11.4 | **13.6** | 16.6 | 20.7 |
| 8,500,000 | 13.15 | 7.45 | 0.86 | 8.2 | 9.4 | 10.8 | 12.8 | **15.3** | 18.6 | 23.1 |
| 9,000,000 | 13.92 | 7.90 | 0.96 | 9.1 | 10.5 | 12.1 | 14.2 | **17.0** | 20.7 | 25.8 |
| 9,500,000 | 14.70 | 8.33 | 1.07 | 10.1 | 11.6 | 13.4 | 15.7 | **18.8** | 22.8 | 28.5 |
| 10,000,000 | 15.47 | 8.76 | 1.19 | 11.1 | 12.7 | 14.8 | 17.3 | **20.8** | 25.1 | 31.2 |
| 11,000,000 | 17.02 | 9.65 | 1.44 | 13.3 | 15.2 | 17.7 | 20.8 | **24.6** | 30.0 | 37.1 |
| 12,000,000 | 18.57 | 10.50 | 1.71 | 15.6 | 17.8 | 20.5 | 24.2 | **29.0** | 35.3 | 43.8 |
| 14,000,000 | 21.66 | 12.3 | 2.35 | 20.9 | 23.8 | 27.3 | 32.2 | **38.8** | 46.8 | 58 |
| 16,000,000 | 24.76 | 14.0 | 3.04 | 26.6 | 30.4 | 35.2 | 41.5 | **49.4** | 60 | 75 |
| 18,000,000 | 27.85 | 15.8 | 3.87 | 32.7 | 37.8 | 43.5 | 51 | **61** | 74 | 92 |
| 20,000,000 | 30.94 | 17.5 | 4.75 | 40.0 | 45.8 | 53 | 63 | **74** | 90 | 113 |

# 20-INCH PIPE.

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gallons per 24 Hours. | Cubic Feet per Second. | | | (00) c=140 | (0) c=130 | (5) c=120 | (11) c=110 | (19) c=100 | (28) c=90 | (41) c=80 |
| 400,000 | 0.619 | 0.28 | 0.00 | 0.017 | 0.020 | 0.023 | 0.027 | **0.032** | 0.039 | 0.048 |
| 600,000 | 0.928 | 0.43 | 0.00 | 0.037 | 0.049 | 0.049 | 0.057 | **0.068** | 0.083 | 0.103 |
| 800,000 | 1.238 | 0.57 | 0.00 | 0.062 | 0.071 | 0.082 | 0.097 | **0.115** | 0.140 | 0.174 |
| 1,000,000 | 1.547 | 0.71 | 0.01 | 0.094 | 0.107 | 0.124 | 0.146 | **0.174** | 0.211 | 0.263 |
| 1,200,000 | 1.857 | 0.85 | 0.01 | 0.131 | 0.150 | 0.174 | 0.205 | **0.243** | 0.297 | 0.370 |
| 1,400,000 | 2.166 | 0.99 | 0.02 | 0.174 | 0.200 | 0.232 | 0.273 | **0.326** | 0.396 | 0.491 |
| 1,600,000 | 2.476 | 1.13 | 0.02 | 0.223 | 0.257 | 0.298 | 0.349 | **0.416** | 0.51 | 0.63 |
| 1,800,000 | 2.785 | 1.28 | 0.03 | 0.278 | 0.319 | 0.370 | 0.435 | **0.52** | 0.63 | 0.78 |
| 2,000,000 | 3.094 | 1.42 | 0.03 | 0.339 | 0.389 | 0.449 | 0.53 | **0.63** | 0.76 | 0.96 |
| 2,500,000 | 3.868 | 1.77 | 0.05 | 0.51 | 0.58 | 0.68 | 0.80 | **0.95** | 1.16 | 1.44 |
| 3,000,000 | 4.642 | 2.13 | 0.07 | 0.72 | 0.82 | 0.95 | 1.12 | **1.33** | 1.61 | 2.02 |
| 3,500,000 | 5.41 | 2.48 | 0.10 | 0.95 | 1.09 | 1.27 | 1.49 | **1.78** | 2.16 | 2.69 |
| 4,000,000 | 6.19 | 2.84 | 0.13 | 1.22 | 1.39 | 1.62 | 1.90 | **2.28** | 2.77 | 3.44 |
| 4,500,000 | 6.96 | 3.19 | 0.16 | 1.52 | 1.74 | 2.02 | 2.38 | **2.83** | 3.44 | 4.29 |
| 5,000,000 | 7.74 | 3.55 | 0.20 | 1.84 | 2.11 | 2.45 | 2.88 | **3.43** | 4.18 | 5.2 |
| 5,500,000 | 8.51 | 3.90 | 0.24 | 2.20 | 2.52 | 2.92 | 3.43 | **4.09** | 4.98 | 6.2 |
| 6,000,000 | 9.28 | 4.26 | 0.28 | 2.59 | 2.97 | 3.44 | 4.03 | **4.81** | 5.8 | 7.3 |
| 6,500,000 | 10.06 | 4.61 | 0.33 | 3.00 | 3.43 | 3.99 | 4.68 | **5.6** | 6.8 | 8.4 |
| 7,000,000 | 10.83 | 4.96 | 0.38 | 3.43 | 3.95 | 4.58 | 5.4 | **6.4** | 7.8 | 9.7 |
| 7,500,000 | 11.60 | 5.32 | 0.44 | 3.90 | 4.48 | 5.2 | 6.1 | **7.3** | 8.8 | 11.0 |
| 8,000,000 | 12.38 | 5.67 | 0.50 | 4.39 | 5.1 | 5.8 | 6.9 | **8.2** | 10.0 | 12.4 |
| 8,500,000 | 13.15 | 6.03 | 0.56 | 4.91 | 5.6 | 6.6 | 7.7 | **9.2** | 11.2 | 13.8 |
| 9.000,000 | 13.92 | 6.38 | 0.63 | 5.5 | 6.3 | 7.3 | 8.6 | **10.2** | 12.4 | 15.4 |
| 9,500,000 | 14.70 | 6.74 | 0.71 | 6.0 | 6.9 | 8.0 | 9.4 | **11.3** | 13.7 | 17.1 |
| 10,000,000 | 15.47 | 7.09 | 0.78 | 6.6 | 7.6 | 8.9 | 10.4 | **12.4** | 15.1 | 18.7 |
| 11 000,000 | 17.02 | 7.80 | 0.94 | 7.9 | 9.1 | 10.6 | 12.4 | **14.8** | 18.0 | 22.4 |
| 12,000,000 | 18.57 | 8.51 | 1.12 | 9.4 | 10.7 | 12.4 | 14.6 | **17.4** | 21.1 | 26.2 |
| 13,000,000 | 20.11 | 9.22 | 1.32 | 10.8 | 12.4 | 14.4 | 16.9 | **20.1** | 24.4 | 30.4 |
| 14,000,000 | 21.66 | 9.93 | 1.53 | 12.4 | 14.2 | 16.5 | 19.4 | **23.1** | 28.1 | 35.0 |
| 15,000,000 | 23.21 | 10.64 | 1.76 | 14.1 | 16.2 | 18.8 | 22.0 | **26.2** | 32.0 | 39.8 |
| 16,000.000 | 24.76 | 11.35 | 2.00 | 15.8 | 18.2 | 21.1 | 24.8 | **29.6** | 36.0 | 44.8 |
| 17,000,000 | 26.30 | 12.06 | 2.25 | 17.7 | 20.4 | 23.8 | 27.9 | **33.1** | 40.2 | 50 |
| 18,000,000 | 27.85 | 12.77 | 2.53 | 19.7 | 22.7 | 26.2 | 30.9 | **36.8** | 44.7 | 56 |
| 19,000,000 | 29.40 | 13.47 | 2.82 | 21.8 | 25.0 | 29.1 | 34.1 | **40.7** | 49.5 | 62 |
| 20,000,000 | 30.94 | 14.18 | 3.13 | 24.0 | 27.6 | 32.0 | 37.5 | **44.8** | 54 | 68 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 $c=140$ | 0 $c=130$ | 5 $c=120$ | 11 $c=110$ | 19 $c=100$ | 29 $c=90$ | 42 $c=80$ |
| 500,000 | 0.774 | 0.25 | 0.00 | 0.011 | 0.012 | 0.014 | 0.017 | **0.020** | 0.024 | 0.030 |
| 1,000,000 | 1.547 | 0.49 | 0.00 | 0.038 | 0.044 | 0.051 | 0.060 | **0.072** | 0.087 | 0.108 |
| 1,500,000 | 2.321 | 0.74 | 0.01 | 0.082 | 0.093 | 0.108 | 0.128 | **0.152** | 0.185 | 0.230 |
| 2,000,000 | 3.094 | 0.98 | 0.01 | 0.138 | 0.159 | 0.185 | 0.218 | **0.259** | 0.314 | 0.391 |
| 2,500,000 | 3.868 | 1.23 | 0.02 | 0.210 | 0.240 | 0.279 | 0.328 | **0.390** | 0.474 | 0.59 |
| 3,000,000 | 4.642 | 1.48 | 0.03 | 0.293 | 0.338 | 0.391 | 0.459 | **0.55** | 0.66 | 0.83 |
| 3,500,000 | 5.41 | 1.72 | 0.05 | 0.391 | 0.449 | 0.52 | 0.61 | **0.73** | 0.89 | 1.11 |
| 4,000,000 | 6.19 | 1.97 | 0.06 | 0.50 | 0.58 | 0.67 | 0.78 | **0.93** | 1.13 | 1.42 |
| 4,500,000 | 6.96 | 2.22 | 0.08 | 0.62 | 0.72 | 0.83 | 0.98 | **1.16** | 1.42 | 1.76 |
| 5,000,000 | 7.74 | 2.46 | 0.09 | 0.76 | 0.87 | 1.02 | 1.18 | **1.41** | 1.72 | 2.14 |
| 5,500,000 | 8.51 | 2.71 | 0.11 | 0.90 | 1.03 | 1.21 | 1.42 | **1.68** | 2.05 | 2.56 |
| 6,000,000 | 9.28 | 2.96 | 0.14 | 1.06 | 1.22 | 1.42 | 1.66 | **1.97** | 2.41 | 2.99 |
| 6,500,000 | 10.06 | 3.20 | 0.16 | 1.23 | 1.41 | 1.64 | 1.93 | **2.29** | 2.79 | 3.48 |
| 7,000,000 | 10.83 | 3.45 | 0.18 | 1.41 | 1.62 | 1.88 | 2.21 | **2.63** | 3.20 | 3.98 |
| 7,500,000 | 11.60 | 3.69 | 0.21 | 1.61 | 1.84 | 2.13 | 2.51 | **2.98** | 3.63 | 4.52 |
| 8,000,000 | 12.38 | 3.94 | 0.24 | 1.81 | 2.07 | 2.41 | 2.83 | **3.38** | 4.09 | 5.1 |
| 8,500,000 | 13.15 | 4.19 | 0.27 | 2.02 | 2.32 | 2.68 | 3.16 | **3.77** | 4.58 | 5.7 |
| 9,000,000 | 13.92 | 4.43 | 0.31 | 2.26 | 2.58 | 2.99 | 3.52 | **4.20** | 5.1 | 6.4 |
| 9,500,000 | 14.70 | 4.68 | 0.34 | 2.48 | 2.85 | 3.31 | 3.89 | **4.62** | 5.6 | 7.0 |
| 10,000,000 | 15.47 | 4.92 | 0.38 | 2.73 | 3.12 | 3.63 | 4.28 | **5.1** | 6.2 | 7.7 |
| 11,000,000 | 17.02 | 5.42 | 0.46 | 3.26 | 3.74 | 4.33 | 5.1 | **6.1** | 7.4 | 9.2 |
| 12,000,000 | 18.57 | 5.91 | 0.54 | 3.82 | 4.39 | 5.1 | 6.0 | **7.1** | 8.7 | 10.8 |
| 13,000,000 | 20.11 | 6.40 | 0.64 | 4.45 | 5.1 | 5.9 | 6.9 | **8.3** | 10.1 | 12.6 |
| 14,000,000 | 21.66 | 6.89 | 0.74 | 5.1 | 5.8 | 6.8 | 8.0 | **9.5** | 11.6 | 14.3 |
| 15,000,000 | 23.21 | 7.39 | 0.85 | 5.8 | 6.6 | 7.7 | 9.1 | **10.8** | 13.2 | 16.3 |
| 16,000,000 | 24.76 | 7.88 | 0.96 | 6.6 | 7.5 | 8.7 | 10.2 | **12.2** | 14.8 | 18.4 |
| 17 000,000 | 26.30 | 8.37 | 1.09 | 7.3 | 8.4 | 9.7 | 11.4 | **13.6** | 16.6 | 20.7 |
| 18,000,000 | 27.85 | 8.86 | 1.22 | 8.1 | 9.3 | 10.8 | 12.7 | **15.2** | 18.4 | 22.9 |
| 19,000,000 | 29.40 | 9.36 | 1.36 | 9.0 | 10.3 | 11.9 | 14.0 | **16.7** | 20.3 | 25.3 |
| 20,000,000 | 30.94 | 9.85 | 1.51 | 9.9 | 11.3 | 13.2 | 15.4 | **18.3** | 22.4 | 27.8 |
| 22,000,000 | 34.04 | 10.83 | 1.82 | 11.8 | 13.5 | 15.7 | 18.4 | **21.9** | 26.7 | 33.1 |
| 24,000,000 | 37.13 | 11.82 | 2.17 | 13.8 | 15.8 | 18.4 | 21.7 | **25.9** | 31.2 | 39.0 |
| 26,000,000 | 40.23 | 12.80 | 2.55 | 16.1 | 18.4 | 21.3 | 25.0 | **29.9** | 36.4 | 45.2 |
| 28,000,000 | 43.32 | 13.79 | 2.96 | 18.3 | 21.1 | 24.5 | 28.8 | **34.2** | 41.9 | 52 |
| 30,000,000 | 46.42 | 14.77 | 3.38 | 20.9 | 24.0 | 27.9 | 32.8 | **39.0** | 47.5 | 59 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 c=140 | 0 c=130 | 6 c=120 | 12 c=110 | 19 c=100 | 30 c=90 | 43 c=80 |
| 1,000,000 | 1.547 | 0.32 | 0.00 | 0.013 | 0.015 | 0.017 | 0.020 | **0.024** | 0.029 | 0.037 |
| 1,500,000 | 2.321 | 0.47 | 0.00 | 0.028 | 0.032 | 0.037 | 0.044 | **0.052** | 0.062 | 0.078 |
| 2,000,000 | 3.094 | 0.63 | 0.01 | 0.047 | 0.054 | 0.062 | 0.073 | **0.087** | 0.106 | 0.132 |
| 2,500,000 | 3.868 | 0.79 | 0.01 | 0.071 | 0.081 | 0.094 | 0.111 | **0.132** | 0.160 | 0.199 |
| 3,000,000 | 4.642 | 0.95 | 0.01 | 0.099 | 0.113 | 0.132 | 0.155 | **0.184** | 0.225 | 0.280 |
| 3,500,000 | 5.41 | 1.10 | 0.02 | 0.132 | 0.151 | 0.176 | 0.206 | **0.247** | 0.298 | 0.372 |
| 4,000,000 | 6.19 | 1.26 | 0.02 | 0.168 | 0.194 | 0.225 | 0.264 | **0.315** | 0.382 | 0.477 |
| 4,500,000 | 6.96 | 1.42 | 0.03 | 0.210 | 0.241 | 0.279 | 0.329 | **0.391** | 0.476 | 0.59 |
| 5,000,000 | 7.74 | 1.58 | 0.04 | 0.256 | 0.292 | 0.340 | 0.399 | **0.476** | 0.58 | 0.72 |
| 5,500,000 | 8.51 | 1.73 | 0.05 | 0.304 | 0.349 | 0.405 | 0.476 | **0.57** | 0.69 | 0.88 |
| 6,000,000 | 9.28 | 1.89 | 0.06 | 0.357 | 0.410 | 0.475 | 0.56 | **0.67** | 0.81 | 1.01 |
| 6,500,000 | 10.06 | 2.05 | 0.07 | 0.414 | 0.475 | 0.55 | 0.65 | **0.78** | 0.94 | 1.17 |
| 7,000,000 | 10.83 | 2.21 | 0.08 | 0.474 | 0.55 | 0.64 | 0.74 | **0.89** | 1.08 | 1.34 |
| 7,500,000 | 11.60 | 2.36 | 0.09 | 0.54 | 0.62 | 0.72 | 0.84 | **1.01** | 1.22 | 1.53 |
| 8,000,000 | 12.38 | 2.52 | 0.10 | 0.61 | 0.70 | 0.81 | 0.95 | **1.13** | 1.38 | 1.72 |
| 8,500 000 | 13.15 | 2.68 | 0.11 | 0.68 | 0.78 | 0.91 | 1.07 | **1.27** | 1.54 | 1.92 |
| 9,000,000 | 13.92 | 2.84 | 0.13 | 0.76 | 0.87 | 1.01 | 1.18 | **1.42** | 1.72 | 2.14 |
| 10,000,000 | 15.47 | 3.15 | 0.15 | 0.92 | 1.06 | 1.23 | 1.44 | **1.72** | 2.09 | 2.60 |
| 11,000,000 | 17.02 | 3.47 | 0.19 | 1.09 | 1.26 | 1.46 | 1.72 | **2.06** | 2.49 | 3.10 |
| 12,000,000 | 18.57 | 3.78 | 0.22 | 1.28 | 1.47 | 1.72 | 2.02 | **2.41** | 2.92 | 3.64 |
| 13,000,000 | 20.11 | 4.10 | 0.26 | 1.50 | 1.72 | 1.98 | 2.34 | **2.79** | 3.40 | 4.21 |
| 14,000,000 | 21.66 | 4.41 | 0.30 | 1.72 | 1.97 | 2.28 | 2.69 | **3.20** | 3.89 | 4.85 |
| 15,000,000 | 23.21 | 4.73 | 0.35 | 1.95 | 2.24 | 2.60 | 3.06 | **3.64** | 4.43 | 5.5 |
| 16,000,000 | 24.76 | 5.04 | 0.40 | 2.20 | 2.52 | 2.93 | 3.45 | **4.10** | 4.99 | 6.2 |
| 17,000,000 | 26.30 | 5.36 | 0.45 | 2.46 | 2.82 | 3.28 | 3.85 | **4.59** | 5.6 | 7.0 |
| 18,000,000 | 27.85 | 5.67 | 0.50 | 2.74 | 3.14 | 3.63 | 4.28 | **5.1** | 6.2 | 7.7 |
| 19,000,000 | 29.40 | 5.99 | 0.56 | 3.02 | 3.47 | 4.01 | 4.72 | **5.6** | 6.8 | 8.6 |
| 20,000,000 | 30.94 | 6.30 | 0.62 | 3.33 | 3.81 | 4.44 | 5.2 | **6.2** | 7.6 | 9.4 |
| 22,000,000 | 34.04 | 6.93 | 0.75 | 3.96 | 4.55 | 5.3 | 6.2 | **7.4** | 9.0 | 11.2 |
| 24,000,000 | 37.13 | 7.56 | 0.89 | 4.65 | 5.4 | 6.2 | 7.3 | **8.7** | 10.6 | 13.2 |
| 26,000,000 | 40.23 | 8.20 | 1.04 | 5.4 | 6.2 | 7.2 | 8.4 | **10.1** | 12.3 | 15.3 |
| 28,000,000 | 43.32 | 8.83 | 1.21 | 6.2 | 7.1 | 8.3 | 9.7 | **11.6** | 14.1 | 17.5 |
| 30,000,000 | 46.42 | 9.46 | 1.39 | 7.1 | 8.1 | 9.4 | 11.0 | **13.2** | 16.0 | 19.8 |
| 35,000,000 | 54.1 | 11.03 | 1.89 | 9.4 | 10.8 | 12.6 | 14.7 | **17.5** | 21.3 | 26.4 |
| 40,000,000 | 61.9 | 12.61 | 2.47 | 12.0 | 13.8 | 16.0 | 18.8 | **22.4** | 27.2 | 33.9 |

# 36-INCH PIPE.

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 c=140 | 0 c=130 | 6 c=120 | 12 c=110 | 20 c=100 | 30 c=90 | 44 c=80 |
| 2 | 3.094 | 0.44 | 0.00 | 0.019 | 0.022 | 0.026 | 0.030 | 0.036 | 0.044 | 0.054 |
| 2.5 | 3.868 | 0.55 | 0.00 | 0.029 | 0.033 | 0.039 | 0.046 | 0.054 | 0.066 | 0.082 |
| 3 | 4.642 | 0.66 | 0.01 | 0.041 | 0.047 | 0.054 | 0.064 | 0.076 | 0.092 | 0.115 |
| 3.5 | 5.41 | 0.77 | 0.01 | 0.054 | 0.062 | 0.072 | 0.085 | 0.102 | 0.123 | 0.153 |
| 4 | 6.19 | 0.88 | 0.01 | 0.070 | 0.080 | 0.092 | 0.108 | 0.129 | 0.157 | 0.196 |
| 5 | 7.74 | 1.09 | 0.02 | 0.105 | 0.121 | 0.140 | 0.164 | 0.196 | 0.238 | 0.297 |
| 6 | 9.28 | 1.31 | 0.03 | 0.147 | 0.168 | 0.196 | 0.230 | 0.274 | 0.333 | 0.415 |
| 7 | 10.83 | 1.53 | 0.04 | 0.196 | 0.224 | 0.260 | 0.306 | 0.365 | 0.444 | 0.55 |
| 8 | 12.38 | 1.75 | 0.05 | 0.250 | 0.288 | 0.332 | 0.391 | 0.467 | 0.57 | 0.71 |
| 9 | 13.92 | 1.97 | 0.06 | 0.311 | 0.358 | 0.415 | 0.488 | 0.58 | 0.71 | 0.88 |
| 10 | 15.47 | 2.19 | 0.07 | 0.379 | 0.434 | 0.50 | 0.59 | 0.71 | 0.86 | 1.07 |
| 11 | 17.02 | 2.41 | 0.09 | 0.451 | 0.52 | 0.60 | 0.70 | 0.84 | 1.02 | 1.28 |
| 12 | 18.57 | 2.63 | 0.11 | 0.53 | 0.61 | 0.71 | 0.83 | 0.99 | 1.21 | 1.50 |
| 13 | 20.11 | 2.85 | 0.13 | 0.62 | 0.71 | 0.82 | 0.96 | 1.15 | 1.39 | 1.74 |
| 14 | 21.66 | 3.06 | 0.15 | 0.71 | 0.81 | 0.94 | 1.11 | 1.32 | 1.60 | 1.98 |
| 15 | 23.21 | 3.28 | 0.17 | 0.80 | 0.92 | 1.07 | 1.26 | 1.49 | 1.82 | 2.27 |
| 16 | 24.76 | 3.50 | 0.19 | 0.90 | 1.03 | 1.21 | 1.42 | 1.68 | 2.05 | 2.56 |
| 17 | 26.30 | 3.72 | 0.22 | 1.02 | 1.16 | 1.34 | 1.58 | 1.88 | 2.30 | 2.86 |
| 18 | 27.85 | 3.94 | 0.24 | 1.12 | 1.29 | 1.50 | 1.76 | 2.10 | 2.56 | 3.18 |
| 19 | 29.40 | 4.16 | 0.27 | 1.24 | 1.43 | 1.66 | 1.94 | 2.32 | 2.81 | 3.51 |
| 20 | 30.94 | 4.38 | 0.30 | 1.37 | 1.57 | 1.82 | 2.14 | 2.55 | 3.10 | 3.86 |
| 22 | 34.04 | 4.82 | 0.36 | 1.63 | 1.87 | 2.17 | 2.55 | 3.04 | 3.69 | 4.60 |
| 24 | 37.13 | 5.25 | 0.43 | 1.92 | 2.20 | 2.55 | 2.99 | 3.58 | 4.35 | 5.4 |
| 26 | 40.23 | 5.69 | 0.50 | 2.22 | 2.55 | 2.96 | 3.48 | 4.14 | 5.1 | 6.3 |
| 28 | 43.32 | 6.13 | 0.58 | 2.55 | 2.92 | 3.39 | 3.98 | 4.76 | 5.8 | 7.2 |
| 30 | 46.42 | 6.57 | 0.67 | 2.90 | 3.32 | 3.86 | 4.53 | 5.4 | 6.6 | 8.2 |
| 32 | 49.51 | 7.00 | 0.76 | 3.27 | 3.74 | 4.33 | 5.1 | 6.1 | 7.4 | 9.2 |
| 34 | 52.6 | 7.44 | 0.86 | 3.65 | 4.19 | 4.86 | 5.7 | 6.8 | 8.3 | 10.3 |
| 36 | 55.7 | 7.88 | 0.96 | 4.07 | 4.67 | 5.4 | 6.4 | 7.6 | 9.2 | 11.4 |
| 38 | 58.8 | 8.32 | 1.07 | 4.50 | 5.2 | 6.0 | 7.0 | 8.4 | 10.2 | 12.7 |
| 40 | 61.9 | 8.76 | 1.19 | 4.95 | 5.7 | 6.6 | 7.8 | 9.2 | 11.2 | 13.9 |
| 45 | 69.6 | 9.85 | 1.50 | 6.2 | 7.1 | 8.2 | 9.6 | 11.4 | 13.9 | 17.4 |
| 50 | 77.4 | 10.95 | 1.86 | 7.5 | 8.6 | 10.0 | 11.7 | 13.9 | 17.0 | 21.1 |
| 55 | 85.1 | 12.04 | 2.25 | 8.9 | 10.2 | 11.8 | 13.9 | 16.6 | 20.2 | 25.1 |
| 60 | 92.8 | 13.13 | 2.68 | 10.4 | 12.1 | 13.9 | 16.4 | 19.6 | 23.8 | 29.7 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 $c=140$ | 0 $c=130$ | 6 $c=120$ | 12 $c=110$ | 20 $c=100$ | 30 $c=90$ | 45 $c=80$ |
| 3 | 4.64 | 0.48 | 0.00 | 0.019 | 0.022 | 0.026 | 0.030 | **0.036** | 0.044 | 0.054 |
| 4 | 6.19 | 0.64 | 0.01 | 0.033 | 0.038 | 0.044 | 0.052 | **0.061** | 0.074 | 0.092 |
| 5 | 7.74 | 0.80 | 0.01 | 0.050 | 0.057 | 0.066 | 0.078 | **0.092** | 0.113 | 0.140 |
| 6 | 9.28 | 0.96 | 0.01 | 0.070 | 0.080 | 0.092 | 0.108 | **0.129** | 0.158 | 0.196 |
| 7 | 10.83 | 1.13 | 0.02 | 0.092 | 0.106 | 0.123 | 0.145 | **0.172** | 0.210 | 0.261 |
| 8 | 12.38 | 1.29 | 0.03 | 0.118 | 0.136 | 0.158 | 0.185 | **0.220** | 0.268 | 0.333 |
| 9 | 13.92 | 1.45 | 0.03 | 0.147 | 0.168 | 0.196 | 0.230 | **0.273** | 0.333 | 0.415 |
| 10 | 15.47 | 1.61 | 0.04 | 0.178 | 0.207 | 0.238 | 0.280 | **0.332** | 0.406 | 0.51 |
| 11 | 17.02 | 1.77 | 0.05 | 0.213 | 0.245 | 0.284 | 0.334 | **0.398** | 0.483 | 0.60 |
| 12 | 18.57 | 1.93 | 0.06 | 0.251 | 0.288 | 0.333 | 0.392 | **0.468** | 0.57 | 0.71 |
| 14 | 21.66 | 2.25 | 0.08 | 0.333 | 0.382 | 0.445 | 0.52 | **0.62** | 0.76 | 0.94 |
| 16 | 24.76 | 2.57 | 0.10 | 0.428 | 0.490 | 0.57 | 0.67 | **0.80** | 0.97 | 1.21 |
| 18 | 27.85 | 2.89 | 0.13 | 0.53 | 0.61 | 0.71 | 0.83 | **0.99** | 1.21 | 1.50 |
| 20 | 30.94 | 3.22 | 0.16 | 0.64 | 0.74 | 0.86 | 1.02 | **1.21** | 1.47 | 1.83 |
| 22 | 34.04 | 3.53 | 0.19 | 0.77 | 0.88 | 1.03 | 1.21 | **1.44** | 1.74 | 2.18 |
| 24 | 37.13 | 3.86 | 0.23 | 0.90 | 1.04 | 1.21 | 1.42 | **1.68** | 2.05 | 2.55 |
| 26 | 40.23 | 4.18 | 0.27 | 1.05 | 1.21 | 1.39 | 1.64 | **1.96** | 2.38 | 2.97 |
| 28 | 43.32 | 4.50 | 0.31 | 1.21 | 1.38 | 1.61 | 1.88 | **2.25** | 2.74 | 3.40 |
| 30 | 46.42 | 4.82 | 0.36 | 1.37 | 1.57 | 1.83 | 2.14 | **2.56** | 3.10 | 3.87 |
| 32 | 49.51 | 5.15 | 0.41 | 1.54 | 1.77 | 2.06 | 2.41 | **2.88** | 3.50 | 4.36 |
| 34 | 52.6 | 5.47 | 0.46 | 1.73 | 1.98 | 2.29 | 2.70 | **3.21** | 3.91 | 4.88 |
| 36 | 55.7 | 5.79 | 0.52 | 1.92 | 2.20 | 2.56 | 3.00 | **3.58** | 4.35 | 5.4 |
| 38 | 58.8 | 6.11 | 0.58 | 2.12 | 2.43 | 2.82 | 3.31 | **3.95** | 4.80 | 6.0 |
| 40 | 61.9 | 6.45 | 0.64 | 2.33 | 2.68 | 3.10 | 3.64 | **4.35** | 5.3 | 6.6 |
| 42 | 65.0 | 6.75 | 0.71 | 2.56 | 2.92 | 3.40 | 3.99 | **4.76** | 5.8 | 7.2 |
| 44 | 68.1 | 7.08 | 0.78 | 2.78 | 3.19 | 3.70 | 4.36 | **5.2** | 6.3 | 7.8 |
| 46 | 71.2 | 7.40 | 0.85 | 3.02 | 3.48 | 4.02 | 4.71 | **5.6** | 6.8 | 8.5 |
| 48 | 74.3 | 7.72 | 0.93 | 3.28 | 3.76 | 4.36 | 5.1 | **6.1** | 7.4 | 9.2 |
| 50 | 77.4 | 8.04 | 1.01 | 3.52 | 4.05 | 4.70 | 5.5 | **6.6** | 8.0 | 10.0 |
| 55 | 85.1 | 8.84 | 1.21 | 4.21 | 4.82 | 5.6 | 6.6 | **7.8** | 9.6 | 11.8 |
| 60 | 92.8 | 9.65 | 1.45 | 4.94 | 5.7 | 6.6 | 7.7 | **9.2** | 11.2 | 13.9 |
| 65 | 100.6 | 10.45 | 1.70 | 5.7 | 6.6 | 7.6 | 9.0 | **10.7** | 13.0 | 16.2 |
| 70 | 108.3 | 11.26 | 1.97 | 6.6 | 7.6 | 8.8 | 10.3 | **12.2** | 14.9 | 18.6 |
| 75 | 116.0 | 12.06 | 2.26 | 7.5 | 8.6 | 10.0 | 11.7 | **13.9** | 16.9 | 21.1 |
| 80 | 123.8 | 12.86 | 2.57 | 8.4 | 9.6 | 11.2 | 13.2 | **15.7** | 19.1 | 23.8 |

| Discharge in: Million Gallons per 24 Hours. | Discharge in: Cubic Feet per Second. | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. (00) c=140 | (0) c=130 | (6) c=120 | (12) c=110 | (20) c=100 | (30) c=90 | (45) c=80 |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 6.19 | 0.49 | 0.00 | 0.017 | 0.020 | 0.023 | 0.027 | **0.032** | 0.039 | 0.048 |
| 5 | 7.74 | 0.62 | 0.01 | 0.026 | 0.030 | 0.035 | 0.041 | **0.048** | 0.059 | 0.073 |
| 6 | 9.28 | 0.74 | 0.01 | 0.036 | 0.042 | 0.048 | 0.057 | **0.068** | 0.082 | 0.102 |
| 8 | 12.38 | 0.98 | 0.01 | 0.062 | 0.071 | 0.082 | 0.097 | **0.115** | 0.140 | 0.174 |
| 10 | 15.47 | 1.23 | 0.02 | 0.094 | 0.107 | 0.124 | 0.146 | **0.174** | 0.212 | 0.263 |
| 12 | 18.57 | 1.48 | 0.03 | 0.131 | 0.150 | 0.174 | 0.204 | **0.243** | 0.297 | 0.369 |
| 14 | 21.66 | 1.72 | 0.05 | 0.174 | 0.199 | 0.232 | 0.272 | **0.324** | 0.395 | 0.490 |
| 16 | 24.76 | 1.97 | 0.06 | 0.222 | 0.256 | 0.298 | 0.349 | **0.417** | 0.51 | 0.63 |
| 18 | 27.85 | 2.22 | 0.08 | 0.277 | 0.319 | 0.369 | 0.433 | **0.52** | 0.63 | 0.78 |
| 20 | 30.94 | 2.46 | 0.09 | 0.338 | 0.387 | 0.449 | 0.53 | **0.63** | 0.76 | 0.95 |
| 22 | 34.04 | 2.71 | 0.11 | 0.401 | 0.460 | 0.54 | 0.63 | **0.75** | 0.91 | 1.13 |
| 24 | 37.13 | 2.96 | 0.14 | 0.472 | 0.54 | 0.63 | 0.74 | **0.88** | 1.07 | 1.33 |
| 26 | 40.23 | 3.20 | 0.16 | 0.55 | 0.63 | 0.73 | 0.86 | **1.02** | 1.24 | 1.54 |
| 28 | 43.32 | 3.45 | 0.18 | 0.63 | 0.72 | 0.84 | 0.98 | **1.17** | 1.43 | 1.77 |
| 30 | 46.42 | 3.69 | 0.21 | 0.72 | 0.82 | 0.95 | 1.12 | **1.33** | 1.62 | 2.02 |
| 32 | 49.51 | 3.94 | 0.24 | 0.80 | 0.92 | 1.07 | 1.26 | **1.50** | 1.83 | 2.27 |
| 34 | 52.6 | 4.19 | 0.27 | 0.90 | 1.03 | 1.19 | 1.41 | **1.68** | 2.03 | 2.54 |
| 36 | 55.7 | 4.43 | 0.31 | 1.00 | 1.15 | 1.33 | 1.57 | **1.87** | 2.28 | 2.82 |
| 38 | 58.8 | 4.68 | 0.34 | 1.11 | 1.27 | 1.48 | 1.73 | **2.07** | 2.51 | 3.12 |
| 40 | 61.9 | 4.92 | 0.38 | 1.22 | 1.39 | 1.62 | 1.90 | **2.28** | 2.77 | 3.44 |
| 42 | 65.0 | 5.17 | 0.41 | 1.33 | 1.53 | 1.77 | 2.08 | **2.49** | 3.02 | 3.76 |
| 44 | 68.1 | 5.42 | 0.45 | 1.45 | 1.67 | 1.93 | 2.28 | **2.71** | 3.29 | 4.10 |
| 46 | 71.2 | 5.66 | 0.50 | 1.58 | 1.81 | 2.09 | 2.47 | **2.94** | 3.58 | 4.45 |
| 48 | 74.3 | 5.91 | 0.54 | 1.71 | 1.96 | 2.28 | 2.67 | **3.19** | 3.88 | 4.81 |
| 50 | 77.4 | 6.16 | 0.59 | 1.84 | 2.12 | 2.46 | 2.88 | **3.44** | 4.18 | 5.2 |
| 55 | 85.1 | 6.77 | 0.71 | 2.19 | 2.52 | 2.92 | 3.43 | **4.09** | 4.97 | 6.2 |
| 60 | 92.8 | 7.39 | 0.85 | 2.58 | 2.97 | 3.44 | 4.04 | **4.80** | 5.9 | 7.3 |
| 65 | 100.6 | 8.00 | 0.99 | 2.99 | 3.43 | 3.98 | 4.68 | **5.6** | 6.8 | 8.4 |
| 70 | 108.3 | 8.62 | 1.15 | 3.43 | 3.94 | 4.58 | 5.4 | **6.4** | 7.8 | 9.7 |
| 75 | 116.0 | 9.23 | 1.32 | 3.90 | 4.48 | 5.2 | 6.1 | **7.3** | 8.8 | 11.0 |
| 80 | 123.8 | 9.85 | 1.51 | 4.40 | 5.1 | 5.9 | 6.9 | **8.2** | 10.0 | 12.4 |
| 85 | 131.5 | 10.48 | 1.70 | 4.92 | 5.6 | 6.6 | 7.7 | **9.2** | 11.2 | 13.8 |
| 90 | 139.2 | 11.08 | 1.91 | 5.5 | 6.3 | 7.3 | 8.6 | **10.2** | 12.4 | 15.4 |
| 95 | 147.0 | 11.69 | 2.12 | 6.0 | 7.0 | 8.0 | 9.5 | **11.3** | 13.7 | 17.1 |
| 100 | 154.7 | 12.31 | 2.35 | 6.7 | 7.6 | 8.8 | 10.4 | **12.4** | 15.1 | 18.8 |

# 54-INCH PIPE.

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | 00 $c=140$ | 0 $c=130$ | 6 $c=120$ | 12 $c=110$ | 20 $c=100$ | 31 $c=90$ | 46 $c=80$ |
| 6 | 9.28 | 0.58 | 0.01 | 0.020 | 0.023 | 0.027 | 0.032 | **0.038** | 0.046 | 0.058 |
| 8 | 12.38 | 0.78 | 0.01 | 0.035 | 0.040 | 0.046 | 0.054 | **0.065** | 0.079 | 0.098 |
| 10 | 15.47 | 0.97 | 0.01 | 0.053 | 0.060 | 0.070 | 0.082 | **0.098** | 0.119 | 0.148 |
| 12 | 18.57 | 1.17 | 0.02 | 0.074 | 0.085 | 0.098 | 0.115 | **0.137** | 0.167 | 0.208 |
| 14 | 21.66 | 1.36 | 0.03 | 0.098 | 0.113 | 0.131 | 0.153 | **0.183** | 0.222 | 0.277 |
| 16 | 24.76 | 1.56 | 0.04 | 0.126 | 0.144 | 0.167 | 0.196 | **0.235** | 0.285 | 0.355 |
| 18 | 27.85 | 1.75 | 0.05 | 0.157 | 0.179 | 0.208 | 0.244 | **0.291** | 0.354 | 0.440 |
| 20 | 30.94 | 1.95 | 0.06 | 0.190 | 0.218 | 0.252 | 0.297 | **0.354** | 0.430 | 0.54 |
| 22 | 34.04 | 2.14 | 0.07 | 0.227 | 0.260 | 0.301 | 0.354 | **0.422** | 0.52 | 0.64 |
| 24 | 37.13 | 2.33 | 0.08 | 0.267 | 0.306 | 0.354 | 0.417 | **0.496** | 0.60 | 0.75 |
| 26 | 40.23 | 2.53 | 0.10 | 0.309 | 0.354 | 0.411 | 0.482 | **0.58** | 0.70 | 0.87 |
| 28 | 43.32 | 2.72 | 0.11 | 0.353 | 0.406 | 0.470 | 0.55 | **0.66** | 0.80 | 1.00 |
| 30 | 46.42 | 2.92 | 0.13 | 0.402 | 0.461 | 0.54 | 0.63 | **0.75** | 0.92 | 1.13 |
| 32 | 49.51 | 3.11 | 0.15 | 0.453 | 0.52 | 0.60 | 0.71 | **0.85** | 1.03 | 1.28 |
| 34 | 52.6 | 3.31 | 0.17 | 0.51 | 0.58 | 0.68 | 0.80 | **0.95** | 1.15 | 1.43 |
| 36 | 55.7 | 3.50 | 0.19 | 0.56 | 0.65 | 0.75 | 0.88 | **1.05** | 1.28 | 1.59 |
| 38 | 58.8 | 3.70 | 0.21 | 0.62 | 0.72 | 0.83 | 0.98 | **1.17** | 1.42 | 1.76 |
| 40 | 61.9 | 3.89 | 0.23 | 0.68 | 0.79 | 0.91 | 1.07 | **1.28** | 1.55 | 1.93 |
| 42 | 65.0 | 4.09 | 0.26 | 0.75 | 0.86 | 1.00 | 1.17 | **1.40** | 1.70 | 2.12 |
| 44 | 68.1 | 4.28 | 0.28 | 0.82 | 0.94 | 1.08 | 1.28 | **1.53** | 1.86 | 2.31 |
| 46 | 71.2 | 4.47 | 0.31 | 0.89 | 1.02 | 1.18 | 1.39 | **1.66** | 2.02 | 2.50 |
| 48 | 74.3 | 4.67 | 0.34 | 0.96 | 1.11 | 1.28 | 1.51 | **1.79** | 2.19 | 2.72 |
| 50 | 77.4 | 4.86 | 0.37 | 1.04 | 1.19 | 1.38 | 1.62 | **1.94** | 2.36 | 2.92 |
| 55 | 85.1 | 5.35 | 0.44 | 1.24 | 1.42 | 1.64 | 1.93 | **2.30** | 2.80 | 3.49 |
| 60 | 92.8 | 5.84 | 0.53 | 1.46 | 1.67 | 1.93 | 2.28 | **2.71** | 3.30 | 4.10 |
| 65 | 100.6 | 6.32 | 0.62 | 1.68 | 1.93 | 2.24 | 2.63 | **3.14** | 3.82 | 4.76 |
| 70 | 108.3 | 6.81 | 0.72 | 1.93 | 2.22 | 2.58 | 3.02 | **3.61** | 4.39 | 5.4 |
| 75 | 116.0 | 7.30 | 0.83 | 2.20 | 2.52 | 2.92 | 3.43 | **4.10** | 4.99 | 6.2 |
| 80 | 123.8 | 7.78 | 0.94 | 2.48 | 2.84 | 3.30 | 3.88 | **4.61** | 5.6 | 7.0 |
| 85 | 131.5 | 8.27 | 1.06 | 2.78 | 3.18 | 3.69 | 4.32 | **5.2** | 6.3 | 7.8 |
| 90 | 139.2 | 8.76 | 1.19 | 3.08 | 3.52 | 4.10 | 4.81 | **5.8** | 7.0 | 8.7 |
| 95 | 147.0 | 9.24 | 1.33 | 3.41 | 3.91 | 4.53 | 5.4 | **6.4** | 7.8 | 9.6 |
| 100 | 154.7 | 9.73 | 1.47 | 3.75 | 4.30 | 4.99 | 5.9 | **7.0** | 8.5 | 10.7 |
| 110 | 170.2 | 10.70 | 1.78 | 4.48 | 5.2 | 6.0 | 7.0 | **8.4** | 10.2 | 12.7 |
| 120 | 185.7 | 11.67 | 2.12 | 5.3 | 6.0 | 7.0 | 8.2 | **9 8** | 11.9 | 14.8 |

| Discharge in: Million Gallons per 24 Hours. | Discharge in: Cubic Feet per Second. | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length: (00) c=140 | (0) c=130 | (6) c=120 | (12) c=110 | (20) c=100 | (31) c=90 | (47) c=80 |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 6.19 | 0.32 | 0.00 | 0.006 | 0.007 | 0.008 | 0.009 | **0.011** | 0.013 | 0.016 |
| 6 | 9.28 | 0.47 | 0.00 | 0.012 | 0.014 | 0.016 | 0.019 | **0.023** | 0.028 | 0.035 |
| 8 | 12.38 | 0.63 | 0.01 | 0.021 | 0.024 | 0.028 | 0.033 | **0.039** | 0.047 | 0.059 |
| 10 | 15.47 | 0.79 | 0.01 | 0.032 | 0.036 | 0.042 | 0.049 | **0.059** | 0.072 | 0.089 |
| 12 | 18.57 | 0.95 | 0.01 | 0.044 | 0.051 | 0.059 | 0.069 | **0.082** | 0.100 | 0.124 |
| 14 | 21.66 | 1.10 | 0.02 | 0.059 | 0.068 | 0.078 | 0.092 | **0.109** | 0.133 | 0.166 |
| 16 | 24.76 | 1.26 | 0.02 | 0.075 | 0.086 | 0.100 | 0.117 | **0.140** | 0.171 | 0.212 |
| 18 | 27.85 | 1.42 | 0.03 | 0.094 | 0.107 | 0.124 | 0.146 | **0.174** | 0.212 | 0.263 |
| 20 | 30.94 | 1.58 | 0.04 | 0.113 | 0.131 | 0.152 | 0.178 | **0.212** | 0.258 | 0.320 |
| 22 | 34.04 | 1.73 | 0.05 | 0.136 | 0.156 | 0.181 | 0.212 | **0.253** | 0.308 | 0.381 |
| 24 | 37.13 | 1.89 | 0.06 | 0.159 | 0.183 | 0.212 | 0.249 | **0.298** | 0.361 | 0.449 |
| 26 | 40.23 | 2.05 | 0.07 | 0.185 | 0.212 | 0.247 | 0.289 | **0.346** | 0.419 | 0.52 |
| 28 | 43.32 | 2.21 | 0.08 | 0.212 | 0.243 | 0.282 | 0.331 | **0.395** | 0.480 | 0.60 |
| 30 | 46.42 | 2.36 | 0.09 | 0.241 | 0.277 | 0.320 | 0.377 | **0.449** | 0.55 | 0.68 |
| 32 | 49.51 | 2.52 | 0.10 | 0.271 | 0.310 | 0.361 | 0.425 | **0.51** | 0.62 | 0.76 |
| 34 | 52.6 | 2.68 | 0.11 | 0.303 | 0.349 | 0.404 | 0.474 | **0.57** | 0.69 | 0.86 |
| 36 | 55.7 | 2.84 | 0.12 | 0.338 | 0.388 | 0.449 | 0.53 | **0.63** | 0.76 | 0.95 |
| 38 | 58.8 | 2.99 | 0.14 | 0.372 | 0.428 | 0.496 | 0.58 | **0.70** | 0.85 | 1.05 |
| 40 | 61.9 | 3.15 | 0.15 | 0.410 | 0.470 | 0.55 | 0.64 | **0.76** | 0.93 | 1.16 |
| 45 | 69.6 | 3.55 | 0.19 | 0.51 | 0.59 | 0.68 | 0.80 | **0.95** | 1.16 | 1.44 |
| 50 | 77.4 | 3.94 | 0.24 | 0.62 | 0.71 | 0.83 | 0.97 | **1.16** | 1.41 | 1.75 |
| 55 | 85.1 | 4.33 | 0.29 | 0.74 | 0.85 | 0.98 | 1.16 | **1.38** | 1.68 | 2.09 |
| 60 | 92.8 | 4.73 | 0.35 | 0.87 | 1.00 | 1.16 | 1.36 | **1.62** | 1.98 | 2.46 |
| 65 | 100.6 | 5.12 | 0.41 | 1.02 | 1.16 | 1.34 | 1.58 | **1.88** | 2.29 | 2.85 |
| 70 | 108.3 | 5.52 | 0.47 | 1.16 | 1.33 | 1.54 | 1.81 | **2.17** | 2.62 | 3.28 |
| 75 | 116.0 | 5.91 | 0.54 | 1.32 | 1.51 | 1.75 | 2.06 | **2.46** | 2.98 | 3.70 |
| 80 | 123.8 | 6.30 | 0.62 | 1.48 | 1.70 | 1.97 | 2.31 | **2.78** | 3.37 | 4.19 |
| 85 | 131.5 | 6.70 | 0.70 | 1.66 | 1.90 | 2.21 | 2.59 | **3.09** | 3.75 | 4.68 |
| 90 | 139.2 | 7.09 | 0.78 | 1.84 | 2.12 | 2.47 | 2.89 | **3.44** | 4.19 | 5.2 |
| 95 | 147.0 | 7.49 | 0.87 | 2.03 | 2.34 | 2.71 | 3.19 | **3.80** | 4.61 | 5.8 |
| 100 | 154.7 | 7.88 | 0.97 | 2.24 | 2.57 | 2.98 | 3.51 | **4.19** | 5.1 | 6.4 |
| 110 | 170.2 | 8.67 | 1.17 | 2.68 | 3.07 | 3.57 | 4.18 | **4.98** | 6.0 | 7.6 |
| 120 | 185.7 | 9.46 | 1.39 | 3.13 | 3.60 | 4.18 | 4.90 | **5.9** | 7.1 | 8.9 |
| 130 | 201.1 | 10.24 | 1.63 | 3.63 | 4.18 | 4.84 | 5.7 | **6.8** | 8.3 | 10.3 |
| 140 | 216.6 | 11.03 | 1.89 | 4.18 | 4.79 | 5.6 | 6.6 | **7.8** | 9.5 | 11.8 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 8 | 12.38 | 0.52 | 0.00 | 0.013 | 0.015 | 0.017 | 0.021 | **0.024** | 0.030 | 0.037 |
| 10 | 15.47 | 0.65 | 0.01 | 0.020 | 0.023 | 0.026 | 0.031 | **0.037** | 0.045 | 0.056 |
| 12 | 18.57 | 0.78 | 0.01 | 0.028 | 0.032 | 0.037 | 0.043 | **0.052** | 0.063 | 0.078 |
| 14 | 21.66 | 0.91 | 0.01 | 0.037 | 0.042 | 0.049 | 0.058 | **0.069** | 0.084 | 0.104 |
| 16 | 24.76 | 1.04 | 0.02 | 0.047 | 0.054 | 0.063 | 0.074 | **0.088** | 0.107 | 0.133 |
| 18 | 27.85 | 1.17 | 0.02 | 0.059 | 0.068 | 0.078 | 0.092 | **0.109** | 0.133 | 0.166 |
| 20 | 30.94 | 1.30 | 0.03 | 0.071 | 0.082 | 0.095 | 0.112 | **0.133** | 0.162 | 0.202 |
| 22 | 34.04 | 1.43 | 0.03 | 0.085 | 0.098 | 0.113 | 0.133 | **0.158** | 0.193 | 0.240 |
| 24 | 37.13 | 1.56 | 0.04 | 0.100 | 0.115 | 0.133 | 0.157 | **0.187** | 0.228 | 0.283 |
| 26 | 40.23 | 1.69 | 0.04 | 0.116 | 0.133 | 0.154 | 0.182 | **0.217** | 0.262 | 0.328 |
| 28 | 43.32 | 1.82 | 0.05 | 0.133 | 0.153 | 0.178 | 0.208 | **0.248** | 0.302 | 0.376 |
| 30 | 46.42 | 1.95 | 0.06 | 0.152 | 0.173 | 0.201 | 0.237 | **0.282** | 0.343 | 0.427 |
| 32 | 49.51 | 2.08 | 0.07 | 0.171 | 0.196 | 0.227 | 0.267 | **0.318** | 0.388 | 0.480 |
| 34 | 52.6 | 2.21 | 0.08 | 0.191 | 0.219 | 0.254 | 0.298 | **0.356** | 0.432 | 0.54 |
| 36 | 55.7 | 2.34 | 0.09 | 0.212 | 0.243 | 0.282 | 0.331 | **0.396** | 0.481 | 0.60 |
| 38 | 58.8 | 2.47 | 0.10 | 0.235 | 0.269 | 0.312 | 0.368 | **0.438** | 0.53 | 0.66 |
| 40 | 61.9 | 2.60 | 0.11 | 0.258 | 0.296 | 0.344 | 0.403 | **0.481** | 0.59 | 0.73 |
| 45 | 69.6 | 2.93 | 0.13 | 0.320 | 0.368 | 0.427 | 0.50 | **0.60** | 0.73 | 0.90 |
| 50 | 77.4 | 3.26 | 0.16 | 0.390 | 0.448 | 0.52 | 0.61 | **0.73** | 0.88 | 1.10 |
| 55 | 85.1 | 3.58 | 0.20 | 0.466 | 0.53 | 0.62 | 0.73 | **0.87** | 1.06 | 1.32 |
| 60 | 92.8 | 3.91 | 0.24 | 0.55 | 0.63 | 0.73 | 0.86 | **1.02** | 1.24 | 1.54 |
| 65 | 100.6 | 4.23 | 0.28 | 0.64 | 0.73 | 0.84 | 0.99 | **1.18** | 1.44 | 1.79 |
| 70 | 108.3 | 4.56 | 0.32 | 0.73 | 0.84 | 0.97 | 1.14 | **1.36** | 1.65 | 2.06 |
| 75 | 116.0 | 4.88 | 0.37 | 0.83 | 0.95 | 1.10 | 1.29 | **1.54** | 1.87 | 2.33 |
| 80 | 123.8 | 5.21 | 0.42 | 0.93 | 1.07 | 1.24 | 1.46 | **1.74** | 2.11 | 2.63 |
| 85 | 131.5 | 5.53 | 0.47 | 1.04 | 1.19 | 1.38 | 1.63 | **1.94** | 2.37 | 2.94 |
| 90 | 139.2 | 5.86 | 0.53 | 1.16 | 1.33 | 1.54 | 1.82 | **2.17** | 2.63 | 3.28 |
| 95 | 147.0 | 6.19 | 0.59 | 1.28 | 1.47 | 1.71 | 2.00 | **2.39** | 2.90 | 3.61 |
| 100 | 154.7 | 6.51 | 0.66 | 1.41 | 1.62 | 1.88 | 2.20 | **2.62** | 3.20 | 3.98 |
| 110 | 170.2 | 7.16 | 0.80 | 1.67 | 1.92 | 2.22 | 2.61 | **3.12** | 3.80 | 4.71 |
| 120 | 185.7 | 7.81 | 0.95 | 1.97 | 2.27 | 2.62 | 3.09 | **3.68** | 4.48 | 5.6 |
| 130 | 201.1 | 8.47 | 1.11 | 2.29 | 2.62 | 3.04 | 3.59 | **4.28** | 5.2 | 6.4 |
| 140 | 216.6 | 9.12 | 1.29 | 2.62 | 3.01 | 3.50 | 4.11 | **4.90** | 6.0 | 7.4 |
| 150 | 232.1 | 9.77 | 1.48 | 2.99 | 3.43 | 3.98 | 4.68 | **5.6** | 6.8 | 8.4 |
| 160 | 247.6 | 10.42 | 1.68 | 3.37 | 3.87 | 4.49 | 5.3 | **6.3** | 7.6 | 9.5 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 8 | 12.38 | 0.44 | 0.00 | 0.009 | 0.010 | 0.011 | 0.013 | **0.016** | 0.019 | 0.024 |
| 10 | 15.47 | 0.55 | 0.00 | 0.013 | 0.015 | 0.017 | 0.020 | **0.024** | 0.029 | 0.037 |
| 12 | 18.57 | 0.66 | 0.01 | 0.018 | 0.021 | 0.024 | 0.028 | **0.034** | 0.041 | 0.051 |
| 14 | 21.66 | 0.77 | 0.01 | 0.024 | 0.028 | 0.032 | 0.038 | **0.045** | 0.055 | 0.068 |
| 16 | 24.76 | 0.88 | 0.01 | 0.031 | 0.035 | 0.041 | 0.048 | **0.058** | 0.070 | 0.088 |
| 18 | 27.85 | 0.98 | 0.02 | 0.038 | 0.044 | 0.051 | 0.060 | **0.072** | 0.087 | 0.108 |
| 20 | 30.94 | 1.09 | 0.02 | 0.047 | 0.054 | 0.062 | 0.073 | **0.087** | 0.106 | 0.132 |
| 22 | 34.04 | 1.20 | 0.02 | 0.056 | 0.064 | 0.074 | 0.087 | **0.104** | 0.126 | 0.157 |
| 24 | 37.13 | 1.31 | 0.03 | 0.066 | 0.075 | 0.087 | 0.103 | **0.122** | 0.148 | 0.185 |
| 26 | 40.23 | 1.42 | 0.03 | 0.076 | 0.087 | 0.102 | 0.118 | **0.142** | 0.172 | 0.215 |
| 28 | 43.32 | 1.53 | 0.04 | 0.087 | 0.100 | 0.116 | 0.136 | **0.162** | 0.197 | 0.246 |
| 30 | 46.42 | 1.64 | 0.04 | 0.099 | 0.113 | 0.132 | 0.155 | **0.185** | 0.225 | 0.279 |
| 32 | 49.51 | 1.75 | 0.05 | 0.112 | 0.128 | 0.148 | 0.174 | **0.208** | 0.252 | 0.315 |
| 34 | 52.6 | 1.86 | 0.05 | 0.125 | 0.143 | 0.166 | 0.195 | **0.232** | 0.282 | 0.351 |
| 36 | 55.7 | 1.97 | 0.06 | 0.138 | 0.159 | 0.185 | 0.217 | **0.259** | 0.315 | 0.391 |
| 38 | 58.8 | 2.08 | 0.07 | 0.153 | 0.176 | 0.204 | 0.240 | **0.287** | 0.348 | 0.432 |
| 40 | 61.9 | 2.19 | 0.07 | 0.169 | 0.193 | 0.225 | 0.263 | **0.315** | 0.382 | 0.476 |
| 45 | 69.6 | 2.46 | 0.09 | 0.210 | 0.241 | 0.280 | 0.329 | **0.391** | 0.477 | 0.59 |
| 50 | 77.4 | 2.74 | 0.12 | 0.255 | 0.292 | 0.340 | 0.399 | **0.477** | 0.58 | 0.72 |
| 55 | 81.5 | 3.01 | 0.14 | 0.304 | 0.349 | 0.405 | 0.476 | **0.57** | 0.69 | 0.86 |
| 60 | 92.8 | 3.28 | 0.17 | 0.358 | 0.410 | 0.476 | 0.56 | **0.67** | 0.81 | 1.02 |
| 65 | 100.6 | 3.56 | 0.20 | 0.414 | 0.475 | 0.55 | 0.65 | **0.78** | 0.94 | 1.17 |
| 70 | 108.3 | 3.83 | 0.23 | 0.476 | 0.55 | 0.64 | 0.74 | **0.88** | 1.08 | 1.34 |
| 75 | 116.0 | 4.10 | 0.26 | 0.54 | 0.62 | 0.72 | 0.84 | **1.01** | 1.23 | 1.53 |
| 80 | 123.8 | 4.38 | 0.30 | 0.61 | 0.70 | 0.81 | 0.96 | **1.14** | 1.38 | 1.72 |
| 90 | 139.2 | 4.92 | 0.38 | 0.76 | 0.87 | 1.01 | 1.18 | **1.42** | 1.72 | 2.14 |
| 100 | 154.7 | 5.47 | 0.47 | 0.92 | 1.07 | 1.23 | 1.44 | **1.72** | 2.10 | 2.60 |
| 110 | 170.2 | 6.02 | 0.56 | 1.10 | 1.27 | 1.47 | 1.72 | **2.05** | 2.49 | 3.10 |
| 120 | 185.7 | 6.57 | 0.67 | 1.28 | 1.48 | 1.72 | 2.01 | **2.40** | 2.92 | 3.64 |
| 130 | 201.1 | 7.11 | 0.79 | 1.50 | 1.72 | 1.99 | 2.34 | **2.79** | 3.40 | 4.21 |
| 140 | 216.6 | 7.66 | 0.91 | 1.72 | 1.97 | 2.29 | 2.69 | **3.20** | 3.90 | 4.84 |
| 150 | 232.1 | 8.21 | 1.05 | 1.95 | 2.24 | 2.60 | 3.05 | **3.62** | 4.41 | 5.5 |
| 160 | 247.6 | 8.76 | 1.19 | 2.20 | 2.52 | 2.92 | 3.43 | **4.10** | 4.99 | 6.2 |
| 170 | 263.0 | 9.30 | 1.34 | 2.46 | 2.82 | 3.28 | 3.85 | **4.59** | 5.6 | 7.0 |
| 180 | 278.5 | 9.85 | 1.51 | 2.73 | 3.13 | 3.63 | 4.29 | **5.1** | 6.2 | 7.8 |

# 78-INCH PIPE.

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 6.46 | 10 | 0.30 | 0.00 | 0.004 | 0.004 | 0.005 | 0.006 | **0.007** | 0.009 | 0.011 |
| 9.69 | 15 | 0.45 | 0.00 | 0.008 | 0.009 | 0.011 | 0.013 | **0.015** | 0.019 | 0.023 |
| 12.93 | 20 | 0.60 | 0.01 | 0.014 | 0.016 | 0.019 | 0.022 | **0.026** | 0.032 | 0.040 |
| 16.16 | 25 | 0.75 | 0.01 | 0.021 | 0.024 | 0.028 | 0.033 | **0.040** | 0.048 | 0.060 |
| 19.39 | 30 | 0.90 | 0.01 | 0.030 | 0.034 | 0.040 | 0.047 | **0.056** | 0.068 | 0.084 |
| 22.62 | 35 | 1.05 | 0.02 | 0.040 | 0.046 | 0.053 | 0.062 | **0.074** | 0.090 | 0.112 |
| 25.85 | 40 | 1.21 | 0.02 | 0.051 | 0.058 | 0.068 | 0.080 | **0.095** | 0.116 | 0.144 |
| 29.08 | 45 | 1.36 | 0.03 | 0.064 | 0.073 | 0.084 | 0.099 | **0.118** | 0.144 | 0.178 |
| 32.32 | 50 | 1.51 | 0.04 | 0.077 | 0.088 | 0.102 | 0.120 | **0.143** | 0.174 | 0.218 |
| 35.55 | 55 | 1.66 | 0.04 | 0.092 | 0.106 | 0.122 | 0.144 | **0.172** | 0.208 | 0.259 |
| 38.78 | 60 | 1.81 | 0.05 | 0.108 | 0.124 | 0.144 | 0.169 | **0.201** | 0.245 | 0.304 |
| 42.01 | 65 | 1.96 | 0.06 | 0.126 | 0.144 | 0.167 | 0.196 | **0.233** | 0.284 | 0.354 |
| 45.24 | 70 | 2.11 | 0.07 | 0.143 | 0.164 | 0.190 | 0.223 | **0.268** | 0.325 | 0.404 |
| 48.47 | 75 | 2.26 | 0.08 | 0.163 | 0.186 | 0.217 | 0.253 | **0.303** | 0.369 | 0.459 |
| 51.7 | 80 | 2.41 | 0.09 | 0.184 | 0.211 | 0.246 | 0.288 | **0.343** | 0.419 | 0.52 |
| 54.9 | 85 | 2.56 | 0.10 | 0.205 | 0.236 | 0.272 | 0.321 | **0.382** | 0.467 | 0.58 |
| 58.2 | 90 | 2.71 | 0.11 | 0.228 | 0.262 | 0.304 | 0.358 | **0.426** | 0.52 | 0.64 |
| 61.4 | 95 | 2.86 | 0.13 | 0.252 | 0.290 | 0.337 | 0.396 | **0.471** | 0.57 | 0.72 |
| 64.6 | 100 | 3.01 | 0.14 | 0.278 | 0.319 | 0.369 | 0.432 | **0.52** | 0.63 | 0.78 |
| 71.1 | 110 | 3.32 | 0.17 | 0.331 | 0.379 | 0.440 | 0.52 | **0.62** | 0.75 | 0.94 |
| 77.5 | 120 | 3.62 | 0.20 | 0.389 | 0.446 | 0.52 | 0.61 | **0.72** | 0.88 | 1.09 |
| 84.0 | 130 | 3.92 | 0.24 | 0.450 | 0.52 | 0.60 | 0.71 | **0.84** | 1.02 | 1.27 |
| 90.5 | 140 | 4.22 | 0.28 | 0.52 | 0.59 | 0.69 | 0.81 | **0.96** | 1.17 | 1.46 |
| 96.9 | 150 | 4.52 | 0.32 | 0.59 | 0.68 | 0.78 | 0.92 | **1.09** | 1.33 | 1.66 |
| 103.4 | 160 | 4.82 | 0.36 | 0.66 | 0.76 | 0.88 | 1.03 | **1.23** | 1.50 | 1.87 |
| 109.9 | 170 | 5.12 | 0.41 | 0.74 | 0.85 | 0.99 | 1.16 | **1.38** | 1.68 | 2.09 |
| 116.3 | 180 | 5.43 | 0.46 | 0.82 | 0.94 | 1.09 | 1.28 | **1.54** | 1.87 | 2.32 |
| 122.8 | 190 | 5.73 | 0.51 | 0.91 | 1.04 | 1.22 | 1.43 | **1.70** | 2.07 | 2.58 |
| 129.3 | 200 | 6.03 | 0.56 | 1.00 | 1.15 | 1.33 | 1.57 | **1.87** | 2.27 | 2.82 |
| 142.2 | 220 | 6.63 | 0.68 | 1.19 | 1.37 | 1.59 | 1.87 | **2.22** | 2.70 | 3.38 |
| 155.1 | 240 | 7.23 | 0.81 | 1.40 | 1.61 | 1.87 | 2.20 | **2.62** | 3.19 | 3.97 |
| 168.0 | 260 | 7.84 | 0.95 | 1.63 | 1.87 | 2.17 | 2.54 | **3.04** | 3.69 | 4.59 |
| 181.0 | 280 | 8.44 | 1.11 | 1.87 | 2.14 | 2.49 | 2.92 | **3.49** | 4.23 | 5.3 |
| 193.9 | 300 | 9.04 | 1.27 | 2.12 | 2.43 | 2.82 | 3.31 | **3.96** | 4.80 | 6.0 |
| 206.8 | 320 | 9.64 | 1.44 | 2.39 | 2.75 | 3.19 | 3.74 | **4.45** | 5.4 | 6.8 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 6.46 | 10 | 0.26 | 0.00 | 0.003 | 0.003 | 0.004 | 0.004 | **0.005** | 0.006 | 0.008 |
| 9.69 | 15 | 0.39 | 0.00 | 0.006 | 0.007 | 0.008 | 0.009 | **0.011** | 0.013 | 0.016 |
| 12.93 | 20 | 0.52 | 0.00 | 0.010 | 0.011 | 0.013 | 0.015 | **0.018** | 0.022 | 0.028 |
| 16.16 | 25 | 0.65 | 0.01 | 0.015 | 0.017 | 0.020 | 0.023 | **0.028** | 0.034 | 0.042 |
| 19.39 | 30 | 0.78 | 0.01 | 0.021 | 0.024 | 0.028 | 0.033 | **0.039** | 0.047 | 0.059 |
| 22.62 | 35 | 0.91 | 0.01 | 0.028 | 0.032 | 0.037 | 0.043 | **0.052** | 0.063 | 0.078 |
| 25.85 | 40 | 1.04 | 0.02 | 0.036 | 0.041 | 0.047 | 0.056 | **0.066** | 0.080 | 0.100 |
| 29.08 | 45 | 1.17 | 0.02 | 0.044 | 0.051 | 0.059 | 0.069 | **0.082** | 0.100 | 0.124 |
| 32.32 | 50 | 1.30 | 0.03 | 0.054 | 0.062 | 0.072 | 0.084 | **0.100** | 0.122 | 0.152 |
| 35.55 | 55 | 1.43 | 0.03 | 0.064 | 0.074 | 0.086 | 0.100 | **0.119** | 0.145 | 0.181 |
| 38.78 | 60 | 1.56 | 0.04 | 0.075 | 0.086 | 0.100 | 0.118 | **0.141** | 0.171 | 0.212 |
| 42.01 | 65 | 1.69 | 0.04 | 0.087 | 0.100 | 0.117 | 0.136 | **0.163** | 0.198 | 0.247 |
| 45.24 | 70 | 1.82 | 0.05 | 0.100 | 0.114 | 0.133 | 0.157 | **0.187** | 0.228 | 0.282 |
| 51.7 | 80 | 2.08 | 0.07 | 0.128 | 0.147 | 0.171 | 0.200 | **0.239** | 0.290 | 0.361 |
| 58.2 | 90 | 2.34 | 0.09 | 0.159 | 0.183 | 0.212 | 0.249 | **0.297** | 0.361 | 0.450 |
| 64.6 | 100 | 2.60 | 0.11 | 0.193 | 0.222 | 0.257 | 0.302 | **0.361** | 0.439 | 0.55 |
| 71.1 | 110 | 2.86 | 0.13 | 0.231 | 0.265 | 0.307 | 0.361 | **0.430** | 0.52 | 0.65 |
| 77.5 | 120 | 3.12 | 0.15 | 0.272 | 0.311 | 0.361 | 0.424 | **0.51** | 0.62 | 0.76 |
| 84.0 | 130 | 3.38 | 0.18 | 0.314 | 0.361 | 0.419 | 0.492 | **0.59** | 0.71 | 0.89 |
| 90.5 | 140 | 3.64 | 0.21 | 0.361 | 0.414 | 0.480 | 0.56 | **0.68** | 0.82 | 1.04 |
| 96.9 | 150 | 3.90 | 0.24 | 0.410 | 0.470 | 0.54 | 0.64 | **0.77** | 0.93 | 1.16 |
| 103.4 | 160 | 4.16 | 0.27 | 0.461 | 0.53 | 0.62 | 0.72 | **0.86** | 1.04 | 1.30 |
| 109.9 | 170 | 4.42 | 0.30 | 0.52 | 0.60 | 0.69 | 0.81 | **0.96** | 1.17 | 1.46 |
| 116.3 | 180 | 4.68 | 0.34 | 0.58 | 0.66 | 0.76 | 0.90 | **1.07** | 1.30 | 1.62 |
| 122.8 | 190 | 4.94 | 0.38 | 0.64 | 0.73 | 0.84 | 0.99 | **1.18** | 1.44 | 1.79 |
| 129.3 | 200 | 5.20 | 0.42 | 0.70 | 0.80 | 0.93 | 1.09 | **1.30** | 1.58 | 1.97 |
| 142.2 | 220 | 5.72 | 0.51 | 0.83 | 0.96 | 1.11 | 1.30 | **1.55** | 1.88 | 2.35 |
| 155.1 | 240 | 6.24 | 0.60 | 0.98 | 1.12 | 1.30 | 1.53 | **1.82** | 2.21 | 2.77 |
| 168.0 | 260 | 6.76 | 0.71 | 1.13 | 1.30 | 1.51 | 1.77 | **2.11** | 2.57 | 3.20 |
| 181.0 | 280 | 7.28 | 0.82 | 1.30 | 1.49 | 1.73 | 2.03 | **2.42** | 2.96 | 3.68 |
| 193.9 | 300 | 7.80 | 0.94 | 1.48 | 1.70 | 1.97 | 2.32 | **2.77** | 3.37 | 4.19 |
| 206.8 | 320 | 8.31 | 1.08 | 1.67 | 1.91 | 2.22 | 2.61 | **3.11** | 3.78 | 4.70 |
| 219.7 | 340 | 8.83 | 1.21 | 1.87 | 2.14 | 2.48 | 2.92 | **3.48** | 4.22 | 5.3 |
| 232.7 | 360 | 9.35 | 1.36 | 2.08 | 2.38 | 2.76 | 3.25 | **3.88** | 4.70 | 5.9 |
| 245.6 | 380 | 9.87 | 1.52 | 2.29 | 2.63 | 3.06 | 3.59 | **4.29** | 5.2 | 6.5 |

# 90-INCH PIPE.

| Discharge in: Million Gallons per 24 Hours. | Discharge in: Cubic Feet per Second. | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 9.69 | 15 | 0.34 | 0.00 | 0.004 | 0.005 | 0.006 | 0.007 | **0.008** | 0.009 | 0.012 |
| 12.93 | 20 | 0.45 | 0.00 | 0.007 | 0.008 | 0.009 | 0.011 | **0.013** | 0.016 | 0.020 |
| 16.16 | 25 | 0.57 | 0.00 | 0.011 | 0.012 | 0.014 | 0.017 | **0.020** | 0.024 | 0.030 |
| 19.39 | 30 | 0.68 | 0.01 | 0.015 | 0.017 | 0.020 | 0.023 | **0.028** | 0.034 | 0.042 |
| 22.62 | 35 | 0.79 | 0.01 | 0.020 | 0.023 | 0.026 | 0.031 | **0.037** | 0.045 | 0.056 |
| 25.85 | 40 | 0.91 | 0.01 | 0.026 | 0.029 | 0.034 | 0.040 | **0.048** | 0.058 | 0.072 |
| 29.08 | 45 | 1.02 | 0.02 | 0.032 | 0.036 | 0.042 | 0.050 | **0.059** | 0.072 | 0.090 |
| 32.32 | 50 | 1.13 | 0.02 | 0.038 | 0.044 | 0.051 | 0.060 | **0.072** | 0.087 | 0.108 |
| 38.78 | 60 | 1.36 | 0.03 | 0.054 | 0.062 | 0.072 | 0.084 | **0.101** | 0.122 | 0.152 |
| 45.24 | 70 | 1.58 | 0.04 | 0.072 | 0.083 | 0.096 | 0.113 | **0.134** | 0.163 | 0.202 |
| 51.7 | 80 | 1.81 | 0.05 | 0.092 | 0.105 | 0.122 | 0.143 | **0.171** | 0.208 | 0.259 |
| 58.2 | 90 | 2.04 | 0.06 | 0.114 | 0.131 | 0.152 | 0.179 | **0.213** | 0.260 | 0.322 |
| 64.6 | 100 | 2.26 | 0.08 | 0.139 | 0.160 | 0.186 | 0.218 | **0.260** | 0.316 | 0.392 |
| 71.1 | 110 | 2.49 | 0.10 | 0.166 | 0.190 | 0.221 | 0.259 | **0.309** | 0.376 | 0.468 |
| 77.5 | 120 | 2.72 | 0.11 | 0.194 | 0.222 | 0.259 | 0.303 | **0.361** | 0.440 | 0.55 |
| 84.0 | 130 | 2.94 | 0.13 | 0.226 | 0.259 | 0.301 | 0.353 | **0.421** | 0.51 | 0.64 |
| 90.5 | 140 | 3.17 | 0.16 | 0.259 | 0.298 | 0.344 | 0.404 | **0.481** | 0.59 | 0.73 |
| 96.9 | 150 | 3.40 | 0.18 | 0.294 | 0.338 | 0.391 | 0.460 | **0.55** | 0.67 | 0.83 |
| 103.4 | 160 | 3.62 | 0.20 | 0.332 | 0.381 | 0.442 | 0.52 | **0.62** | 0.76 | 0.94 |
| 109.9 | 170 | 3.85 | 0.23 | 0.371 | 0.425 | 0.493 | 0.58 | **0.69** | 0.84 | 1.04 |
| 116.3 | 180 | 4.07 | 0.26 | 0.413 | 0.472 | 0.55 | 0.64 | **0.77** | 0.94 | 1.17 |
| 122.8 | 190 | 4.30 | 0.29 | 0.457 | 0.52 | 0.61 | 0.72 | **0.85** | 1.03 | 1.29 |
| 129.3 | 200 | 4.53 | 0.32 | 0.50 | 0.58 | 0.67 | 0.78 | **0.94** | 1.14 | 1.42 |
| 142.2 | 220 | 4.98 | 0.39 | 0.60 | 0.69 | 0.80 | 0.94 | **1.12** | 1.36 | 1.69 |
| 155.1 | 240 | 5.43 | 0.46 | 0.70 | 0.81 | 0.94 | 1.10 | **1.31** | 1.59 | 1.98 |
| 168.0 | 260 | 5.89 | 0.54 | 0.82 | 0.94 | 1.08 | 1.27 | **1.52** | 1.84 | 2.30 |
| 181.0 | 280 | 6.34 | 0.62 | 0.93 | 1.07 | 1.24 | 1.46 | **1.74** | 2.11 | 2.62 |
| 193.9 | 300 | 6.77 | 0.72 | 1.07 | 1.21 | 1.41 | 1.65 | **1.97** | 2.40 | 2.98 |
| 206.8 | 320 | 7.25 | 0.82 | 1.19 | 1.37 | 1.58 | 1.86 | **2.22** | 2.70 | 3.38 |
| 219.7 | 340 | 7.70 | 0.92 | 1.33 | 1.53 | 1.78 | 2.09 | **2.49** | 3.02 | 3.78 |
| 232.7 | 360 | 8.15 | 1.03 | 1.49 | 1.71 | 1.98 | 2.32 | **2.78** | 3.39 | 4.20 |
| 245.6 | 380 | 8.60 | 1.15 | 1.65 | 1.89 | 2.20 | 2.58 | **3.08** | 3.73 | 4.65 |
| 258.5 | 400 | 9.05 | 1.27 | 1.81 | 2.08 | 2.41 | 2.82 | **3.38** | 4.10 | 5.1 |
| 271.5 | 420 | 9.51 | 1.40 | 1.98 | 2.28 | 2.63 | 3.10 | **3.70** | 4.50 | 5.6 |
| 284.4 | 440 | 9.96 | 1.54 | 2.17 | 2.48 | 2.89 | 3.39 | **4.02** | 4.90 | 6.1 |

# 96-INCH PIPE.

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 9.69 | 15 | 0.30 | 0.00 | 0.003 | 0.003 | 0.004 | 0.005 | **0.006** | 0.007 | 0.009 |
| 12.93 | 20 | 0.40 | 0.00 | 0.005 | 0.006 | 0.007 | 0.008 | **0.010** | 0.012 | 0.015 |
| 19.39 | 30 | 0.60 | 0.01 | 0.011 | 0.013 | 0.015 | 0.017 | **0.020** | 0.025 | 0.031 |
| 25.85 | 40 | 0.80 | 0.01 | 0.019 | 0.021 | 0.025 | 0.029 | **0.035** | 0.042 | 0.053 |
| 32.32 | 50 | 0.99 | 0.02 | 0.028 | 0.032 | 0.037 | 0.043 | **0.052** | 0.063 | 0.078 |
| 38.78 | 60 | 1.19 | 0.02 | 0.039 | 0.045 | 0.052 | 0.061 | **0.073** | 0.089 | 0.110 |
| 45.24 | 70 | 1.39 | 0.03 | 0.052 | 0.060 | 0.070 | 0.082 | **0.097** | 0.118 | 0.147 |
| 51.7 | 80 | 1.59 | 0.04 | 0.067 | 0.077 | 0.089 | 0.104 | **0.124** | 0.152 | 0.188 |
| 58.2 | 90 | 1.79 | 0.05 | 0.083 | 0.095 | 0.111 | 0.130 | **0.155** | 0.188 | 0.234 |
| 64.6 | 100 | 1.99 | 0.06 | 0.101 | 0.116 | 0.135 | 0.158 | **0.188** | 0.229 | 0.286 |
| 71.1 | 110 | 2.19 | 0.07 | 0.121 | 0.138 | 0.161 | 0.188 | **0.226** | 0.273 | 0.341 |
| 77.5 | 120 | 2.39 | 0.09 | 0.143 | 0.163 | 0.190 | 0.222 | **0.267** | 0.322 | 0.401 |
| 84.0 | 130 | 2.59 | 0.10 | 0.165 | 0.189 | 0.220 | 0.259 | **0.308** | 0.374 | 0.466 |
| 90.5 | 140 | 2.79 | 0.12 | 0.189 | 0.218 | 0.251 | 0.297 | **0.352** | 0.429 | 0.54 |
| 96.9 | 150 | 2.99 | 0.14 | 0.216 | 0.248 | 0.288 | 0.338 | **0.401** | 0.489 | 0.61 |
| 103.4 | 160 | 3.19 | 0.16 | 0.242 | 0.279 | 0.322 | 0.380 | **0.451** | 0.55 | 0.68 |
| 109.9 | 170 | 3.39 | 0.18 | 0.271 | 0.311 | 0.361 | 0.425 | **0.51** | 0.62 | 0.76 |
| 116.3 | 180 | 3.59 | 0.20 | 0.302 | 0.348 | 0.402 | 0.471 | **0.56** | 0.68 | 0.86 |
| 122.8 | 190 | 3.78 | 0.22 | 0.332 | 0.381 | 0.442 | 0.52 | **0.62** | 0.85 | 0.94 |
| 129.3 | 200 | 3.98 | 0.25 | 0.366 | 0.420 | 0.488 | 0.57 | **0.68** | 0.83 | 1.03 |
| 142.2 | 220 | 4.38 | 0.30 | 0.437 | 0.50 | 0.58 | 0.68 | **0.81** | 0.99 | 1.23 |
| 155.1 | 240 | 4.77 | 0.36 | 0.52 | 0.59 | 0.68 | 0.80 | **0.95** | 1.17 | 1.45 |
| 168.0 | 260 | 5.17 | 0.42 | 0.60 | 0.68 | 0.79 | 0.93 | **1.11** | 1.34 | 1.68 |
| 181.0 | 280 | 5.57 | 0.48 | 0.68 | 0.78 | 0.91 | 1.07 | **1.27** | 1.55 | 1.93 |
| 193.9 | 300 | 5.97 | 0.55 | 0.78 | 0.89 | 1.03 | 1.22 | **1.45** | 1.76 | 2.19 |
| 206.8 | 320 | 6.37 | 0.63 | 0.87 | 1.00 | 1.16 | 1.36 | **1.63** | 1.98 | 2.46 |
| 219.7 | 340 | 6.76 | 0.71 | 0.98 | 1.12 | 1.30 | 1.53 | **1.82** | 2.22 | 2 76 |
| 232.7 | 360 | 7.16 | 0.80 | 1.08 | 1.25 | 1.44 | 1.70 | **2.02** | 2.47 | 3.07 |
| 245.6 | 380 | 7.56 | 0.89 | 1.20 | 1.38 | 1.60 | 1.88 | **2.24** | 2.72 | 3.39 |
| 258.5 | 400 | 7.96 | 0.98 | 1.32 | 1.52 | 1 76 | 2.07 | **2.48** | 3.00 | 3.73 |
| 271.5 | 420 | 8.36 | 1.09 | 1.44 | 1.66 | 1.92 | 2.27 | **2.69** | 3.28 | 4.08 |
| 284.4 | 440 | 8.75 | 1.19 | 1.58 | 1.81 | 2.10 | 2.47 | **2.93** | 3.58 | 4.45 |
| 297.3 | 460 | 9.15 | 1.30 | 1.71 | 1.96 | 2.28 | 2.68 | **3.19** | 3.88 | 4.82 |
| 310.2 | 480 | 9.55 | 1.42 | 1.86 | 2.13 | 2.48 | 2.90 | **3.46** | 4.21 | 5.2 |
| 323.2 | 500 | 9.95 | 1.54 | 2.00 | 2.29 | 2.66 | 3.12 | **3.72** | 4.52 | 5.6 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 12.93 | 20 | 0.35 | 0.00 | 0.004 | 0.004 | 0.005 | 0.006 | **0.007** | 0.009 | 0.011 |
| 19.39 | 30 | 0.53 | 0.00 | 0.008 | 0.009 | 0.011 | 0.013 | **0.015** | 0.018 | 0.023 |
| 25.85 | 40 | 0.70 | 0.01 | 0.014 | 0.016 | 0.018 | 0.022 | **0.026** | 0.031 | 0.039 |
| 32.32 | 50 | 0.88 | 0.01 | 0.021 | 0.024 | 0.028 | 0.033 | **0.039** | 0.047 | 0.059 |
| 38.78 | 60 | 1.06 | 0.02 | 0.029 | 0.034 | 0.039 | 0.046 | **0.055** | 0.066 | 0.082 |
| 45.24 | 70 | 1.23 | 0.02 | 0.039 | 0.045 | 0.052 | 0.061 | **0.073** | 0.088 | 0.110 |
| 51.7 | 80 | 1.41 | 0.03 | 0.050 | 0.057 | 0.066 | 0.078 | **0.093** | 0.113 | 0.141 |
| 58.2 | 90 | 1.59 | 0.04 | 0.062 | 0.071 | 0.083 | 0.097 | **0.116** | 0.141 | 0.175 |
| 64.6 | 100 | 1.76 | 0.05 | 0.076 | 0.086 | 0.101 | 0.118 | **0.141** | 0.171 | 0.212 |
| 71.1 | 110 | 1.94 | 0.06 | 0.090 | 0.103 | 0.119 | 0.141 | **0.167** | 0.204 | 0.253 |
| 77.5 | 120 | 2.11 | 0.07 | 0.106 | 0.122 | 0.141 | 0.165 | **0.197** | 0.239 | 0.298 |
| 84.0 | 130 | 2.29 | 0.08 | 0.123 | 0.141 | 0.163 | 0.192 | **0.228** | 0.278 | 0.345 |
| 90.5 | 140 | 2.47 | 0.09 | 0.141 | 0.162 | 0.187 | 0.220 | **0.262** | 0.319 | 0.398 |
| 96.9 | 150 | 2.64 | 0.11 | 0.159 | 0.182 | 0.212 | 0.249 | **0.298** | 0.361 | 0.450 |
| 103.4 | 160 | 2.82 | 0.12 | 0.180 | 0.207 | 0.239 | 0.281 | **0.335** | 0.408 | 0.51 |
| 109.9 | 170 | 3.00 | 0.14 | 0.201 | 0.231 | 0.268 | 0.315 | **0.375** | 0.456 | 0.57 |
| 116.3 | 180 | 3.17 | 0.16 | 0.224 | 0.258 | 0.299 | 0.350 | **0.417** | 0.51 | 0.63 |
| 122.8 | 190 | 3.35 | 0.17 | 0.248 | 0.283 | 0.330 | 0.388 | **0.461** | 0.56 | 0.70 |
| 129.3 | 200 | 3.52 | 0.19 | 0.272 | 0.311 | 0.361 | 0.424 | **0.51** | 0.62 | 0.77 |
| 142.2 | 220 | 3.88 | 0.23 | 0.323 | 0.371 | 0.431 | 0.51 | **0.60** | 0.74 | 0.92 |
| 155.1 | 240 | 4.23 | 0.28 | 0.381 | 0.438 | 0.51 | 0.60 | **0.71** | 0.86 | 1.07 |
| 168.0 | 260 | 4.58 | 0.33 | 0.441 | 0.51 | 0.59 | 0.69 | **0.82** | 1.00 | 1.25 |
| 181.0 | 280 | 4.93 | 0.38 | 0.51 | 0.58 | 0.68 | 0.79 | **0.94** | 1.14 | 1.43 |
| 193.9 | 300 | 5.29 | 0.44 | 0.58 | 0.66 | 0.77 | 0.90 | **1.08** | 1.31 | 1.63 |
| 206.8 | 320 | 5.64 | 0.49 | 0.65 | 0.74 | 0.86 | 1.02 | **1.22** | 1.47 | 1.83 |
| 219.7 | 340 | 5.99 | 0.56 | 0.73 | 0.84 | 0.97 | 1.13 | **1.36** | 1.65 | 2.05 |
| 232.7 | 360 | 6.34 | 0.62 | 0.81 | 0.93 | 1.07 | 1.27 | **1.51** | 1.83 | 2.28 |
| 245.6 | 380 | 6.70 | 0.70 | 0.89 | 1.03 | 1.18 | 1.39 | **1.67** | 2.02 | 2.52 |
| 258.5 | 400 | 7.05 | 0.77 | 0.98 | 1.13 | 1.31 | 1.53 | **1.83** | 2.23 | 2.77 |
| 271.5 | 420 | 7.40 | 0.85 | 1.08 | 1.23 | 1.43 | 1.68 | **2.00** | 2.44 | 3.02 |
| 284.4 | 440 | 7.75 | 0.93 | 1.17 | 1.34 | 1.56 | 1.83 | **2.19** | 2.67 | 3.30 |
| 297.3 | 460 | 8.10 | 1.02 | 1.27 | 1.46 | 1.69 | 1.98 | **2.38** | 2.89 | 3.59 |
| 310.2 | 480 | 8.46 | 1.11 | 1.38 | 1.58 | 1.83 | 2.16 | **2.58** | 3.12 | 3.89 |
| 323.2 | 500 | 8.81 | 1.20 | 1.48 | 1.71 | 1.98 | 2.32 | **2.78** | 3.38 | 4.20 |
| 355.5 | 550 | 9.69 | 1.46 | 1.77 | 2.02 | 2.36 | 2.76 | **3.30** | 4.01 | 4.99 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 12.93 | 20 | 0.31 | 0.00 | 0.003 | 0.004 | 0.004 | 0.005 | **0.006** | 0.008 | 0.009 |
| 19.39 | 30 | 0.47 | 0.00 | 0.006 | 0.007 | 0.008 | 0.010 | **0.011** | 0.014 | 0.017 |
| 25.85 | 40 | 0.63 | 0.01 | 0.010 | 0.012 | 0.014 | 0.016 | **0.019** | 0.024 | 0.029 |
| 32.32 | 50 | 0.79 | 0.01 | 0.016 | 0.018 | 0.021 | 0.025 | **0.029** | 0.036 | 0.045 |
| 38.78 | 60 | 0.94 | 0.01 | 0.022 | 0.025 | 0.029 | 0.035 | **0.041** | 0.050 | 0.062 |
| 45.24 | 70 | 1.10 | 0.02 | 0.029 | 0.034 | 0.039 | 0.046 | **0.055** | 0.067 | 0.083 |
| 51.7 | 80 | 1.26 | 0.02 | 0.038 | 0.043 | 0.050 | 0.059 | **0.070** | 0.086 | 0.107 |
| 58.2 | 90 | 1.41 | 0.03 | 0.047 | 0.054 | 0.062 | 0.073 | **0.087** | 0.106 | 0.132 |
| 64.6 | 100 | 1.57 | 0.04 | 0.057 | 0.066 | 0.076 | 0.089 | **0.106** | 0.128 | 0.161 |
| 71.1 | 110 | 1.73 | 0.05 | 0.068 | 0.078 | 0.090 | 0.106 | **0.126** | 0.153 | 0.191 |
| 77.5 | 120 | 1.89 | 0.06 | 0.080 | 0.092 | 0.106 | 0.124 | **0.148** | 0.181 | 0.225 |
| 84.0 | 130 | 2.04 | 0.07 | 0.092 | 0.106 | 0.123 | 0.144 | **0.172** | 0.209 | 0.261 |
| 90.5 | 140 | 2.20 | 0.08 | 0.107 | 0.122 | 0.141 | 0.166 | **0.198** | 0.240 | 0.299 |
| 96.9 | 150 | 2.36 | 0.09 | 0.122 | 0.138 | 0.161 | 0.188 | **0.225** | 0.273 | 0.340 |
| 103.4 | 160 | 2.52 | 0.10 | 0.136 | 0.156 | 0.181 | 0.212 | **0.252** | 0.309 | 0.382 |
| 116.3 | 180 | 2.83 | 0.12 | 0.169 | 0.194 | 0.225 | 0.264 | **0.314** | 0.382 | 0.477 |
| 129.3 | 200 | 3.14 | 0.15 | 0.206 | 0.237 | 0.272 | 0.321 | **0.382** | 0.466 | 0.58 |
| 142.2 | 220 | 3.46 | 0.19 | 0.246 | 0.281 | 0.326 | 0.382 | **0.457** | 0.56 | 0.70 |
| 155.1 | 240 | 3.77 | 0.22 | 0.289 | 0.330 | 0.382 | 0.450 | **0.54** | 0.65 | 0.81 |
| 168.0 | 260 | 4.09 | 0.26 | 0.335 | 0.384 | 0.445 | 0.52 | **0.62** | 0.76 | 0.94 |
| 181.0 | 280 | 4.40 | 0.30 | 0.382 | 0.440 | 0.51 | 0.60 | **0.72** | 0.87 | 1.08 |
| 193.9 | 300 | 4.72 | 0.35 | 0.436 | 0.50 | 0.58 | 0.68 | **0.81** | 0.99 | 1.23 |
| 206.8 | 320 | 5.03 | 0.39 | 0.491 | 0.56 | 0.66 | 0.77 | **0.92** | 1.12 | 1.38 |
| 219.7 | 340 | 5.34 | 0.44 | 0.55 | 0.63 | 0.73 | 0.86 | **1.03** | 1.24 | 1.55 |
| 232.7 | 360 | 5.66 | 0.50 | 0.61 | 0.70 | 0.81 | 0.96 | **1.14** | 1.38 | 1.72 |
| 245.6 | 380 | 5.97 | 0.55 | 0.68 | 0.78 | 0.90 | 1.06 | **1.26** | 1.53 | 1.90 |
| 258.5 | 400 | 6.29 | 0.61 | 0.74 | 0.85 | 0.99 | 1.16 | **1.38** | 1.68 | 2.09 |
| 271.5 | 420 | 6.60 | 0.68 | 0.81 | 0.93 | 1.08 | 1.27 | **1.51** | 1.84 | 2.29 |
| 284.4 | 440 | 6.92 | 0.74 | 0.88 | 1.02 | 1.18 | 1.38 | **1.65** | 2.00 | 2.49 |
| 297.3 | 460 | 7.23 | 0.81 | 0.96 | 1.11 | 1.28 | 1.50 | **1.78** | 2.18 | 2.71 |
| 310.2 | 480 | 7.55 | 0.88 | 1.04 | 1.19 | 1.38 | 1.63 | **1.94** | 2.36 | 2.93 |
| 323.2 | 500 | 7.86 | 0.96 | 1.12 | 1.28 | 1.49 | 1.75 | **2.09** | 2.54 | 3.17 |
| 355.5 | 550 | 8.65 | 1.16 | 1.34 | 1.54 | 1.78 | 2.09 | **2.50** | 3.03 | 3.79 |
| 387.8 | 600 | 9.43 | 1.38 | 1.57 | 1.81 | 2.09 | 2.47 | **2.93** | 3.58 | 4.42 |
| 420.1 | 650 | 10.22 | 1.62 | 1.82 | 2.09 | 2.42 | 2.85 | **3.40** | 4.12 | 5.20 |

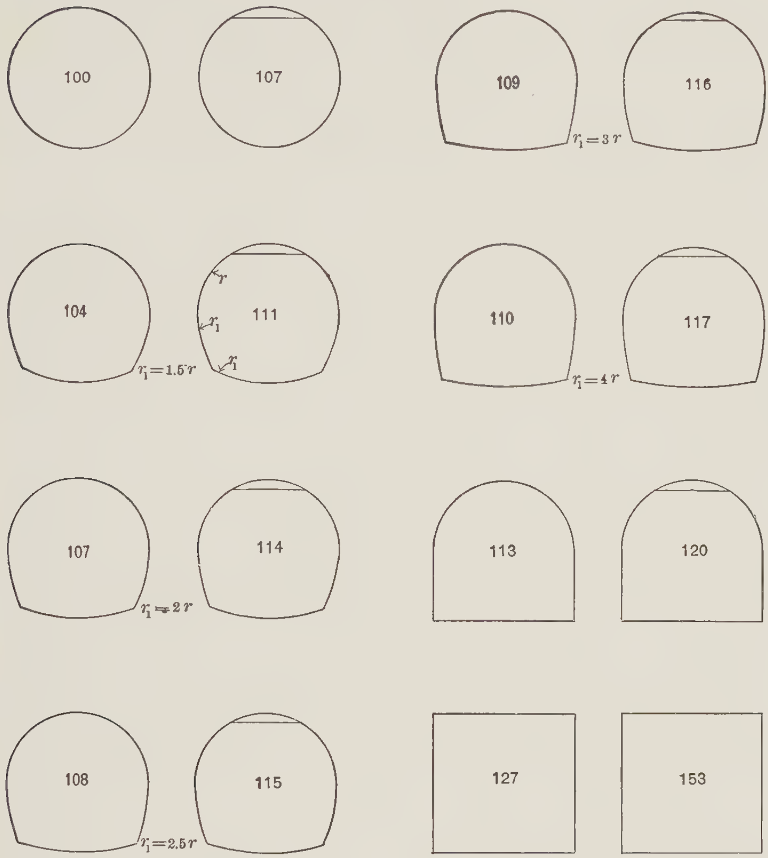
| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 19.39 | 30 | 0 42 | 0.00 | 0.004 | 0.005 | 0.006 | 0.007 | **0.009** | 0.011 | 0.013 |
| 25.85 | 40 | 0.56 | 0.00 | 0.008 | 0.009 | 0.011 | 0.013 | **0.015** | 0.018 | 0.023 |
| 32.32 | 50 | 0.71 | 0.01 | 0.012 | 0.014 | 0.016 | 0.019 | **0.023** | 0.028 | 0.034 |
| 38.78 | 60 | 0.85 | 0.01 | 0.017 | 0.019 | 0.023 | 0.027 | **0.032** | 0.038 | 0.048 |
| 45.24 | 70 | 0.99 | 0.02 | 0.023 | 0.026 | 0.030 | 0.035 | **0.042** | 0.051 | 0.064 |
| 51.7 | 80 | 1.13 | 0.02 | 0.029 | 0.033 | 0.038 | 0.045 | **0.054** | 0.066 | 0.082 |
| 58.2 | 90 | 1.27 | 0.03 | 0.036 | 0.041 | 0.048 | 0.056 | **0.067** | 0.082 | 0.102 |
| 64.6 | 100 | 1.41 | 0.03 | 0.044 | 0.050 | 0.059 | 0.068 | **0.082** | 0.099 | 0.123 |
| 71.1 | 110 | 1.55 | 0.04 | 0.052 | 0.060 | 0.069 | 0.082 | **0.097** | 0.118 | 0.147 |
| 77.5 | 120 | 1.69 | 0.04 | 0.061 | 0.070 | 0.082 | 0.096 | **0.114** | 0.138 | 0.173 |
| 84.0 | 130 | 1.83 | 0.05 | 0.071 | 0.081 | 0.094 | 0.112 | **0.132** | 0.161 | 0.200 |
| 90.5 | 140 | 1.98 | 0.06 | 0.081 | 0.094 | 0.108 | 0.127 | **0.152** | 0.185 | 0.230 |
| 96.9 | 150 | 2.12 | 0.07 | 0.093 | 0.106 | 0.123 | 0.145 | **0.173** | 0.210 | 0.261 |
| 103.4 | 160 | 2.26 | 0.08 | 0.104 | 0.120 | 0.139 | 0.163 | **0.195** | 0.237 | 0.294 |
| 116.3 | 180 | 2.54 | 0.10 | 0.130 | 0.149 | 0.173 | 0.202 | **0.242** | 0.295 | 0.367 |
| 129.3 | 200 | 2.82 | 0.12 | 0.158 | 0.181 | 0.210 | 0.248 | **0.294** | 0.358 | 0.446 |
| 142.2 | 220 | 3.10 | 0.15 | 0.188 | 0.217 | 0.251 | 0.294 | **0.351** | 0.428 | 0.53 |
| 155.1 | 240 | 3.38 | 0.18 | 0.221 | 0.253 | 0.294 | 0.347 | **0.412** | 0.50 | 0.62 |
| 168.0 | 260 | 3.67 | 0.21 | 0.257 | 0.294 | 0.341 | 0.401 | **0.479** | 0.58 | 0.72 |
| 181.0 | 280 | 3.95 | 0.24 | 0.294 | 0.338 | 0.391 | 0.460 | **0.55** | 0.67 | 0.83 |
| 193.9 | 300 | 4.23 | 0.28 | 0.333 | 0.382 | 0.445 | 0.52 | **0.62** | 0.76 | 0.94 |
| 206.8 | 320 | 4.52 | 0.32 | 0.377 | 0.432 | 0.50 | 0.59 | **0.70** | 0.86 | 1.07 |
| 219.7 | 340 | 4.80 | 0.36 | 0.421 | 0.482 | 0 56 | 0.66 | **0.79** | 0.96 | 1.19 |
| 232.7 | 360 | 5.08 | 0.40 | 0.469 | 0.54 | 0.63 | 0.73 | **0.88** | 1.07 | 1.32 |
| 245.6 | 380 | 5.36 | 0.45 | 0.52 | 0.60 | 0.69 | 0.81 | **0.97** | 1.17 | 1.46 |
| 258.5 | 400 | 5.64 | 0.50 | 0.57 | 0.65 | 0.76 | 0.89 | **1.07** | 1.29 | 1.61 |
| 271.5 | 420 | 5.93 | 0.55 | 0.62 | 0.72 | 0.83 | 0.98 | **1.17** | 1.42 | 1.76 |
| 284.4 | 440 | 6.21 | 0.60 | 0.68 | 0.78 | 0.90 | 1.07 | **1.27** | 1.54 | 1.92 |
| 297.3 | 460 | 6.49 | 0.65 | 0.74 | 0.85 | 0.98 | 1.16 | **1.38** | 1.67 | 2.08 |
| 310.2 | 480 | 6.77 | 0.71 | 0.80 | 0.92 | 1.07 | 1.25 | **1.48** | 1.82 | 2.26 |
| 323.2 | 500 | 7.06 | 0.77 | 0.86 | 0.99 | 1.14 | 1.34 | **1.61** | 1.95 | 2.43 |
| 355.5 | 550 | 7 76 | 0.94 | 1.03 | 1.18 | 1.37 | 1.61 | **1.92** | 2.33 | 2.90 |
| 387.8 | 600 | 8 47 | 1.11 | 1.21 | 1.38 | 1.61 | 1.88 | **2.25** | 2.74 | 3.40 |
| 420.1 | 650 | 9.17 | 1.31 | 1.40 | 1.61 | 1.87 | 2.19 | **2.61** | 3.18 | 3.96 |
| 452.4 | 700 | 9.88 | 1.52 | 1.61 | 1.84 | 2.14 | 2.51 | **2.99** | 3.64 | 4.52 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 19.39 | 30 | 0.38 | 0.00 | 0.004 | 0.004 | 0.005 | 0.006 | **0.007** | 0.008 | 0.010 |
| 25.85 | 40 | 0.51 | 0.00 | 0.006 | 0.007 | 0.008 | 0.010 | **0.012** | 0.014 | 0.018 |
| 32.32 | 50 | 0.64 | 0.01 | 0.009 | 0.011 | 0.013 | 0.015 | **0.018** | 0.021 | 0.027 |
| 38.78 | 60 | 0.76 | 0.01 | 0.013 | 0.015 | 0.018 | 0.021 | **0.025** | 0.030 | 0.037 |
| 45.24 | 70 | 0.89 | 0.01 | 0.018 | 0.020 | 0.023 | 0.027 | **0.033** | 0.040 | 0.050 |
| 51.7 | 80 | 1.02 | 0.02 | 0.022 | 0.026 | 0.030 | 0.035 | **0.042** | 0.051 | 0.063 |
| 58.2 | 90 | 1.15 | 0.02 | 0.028 | 0.032 | 0.037 | 0.044 | **0.052** | 0.064 | 0.079 |
| 64.6 | 100 | 1.27 | 0.03 | 0.034 | 0.039 | 0.045 | 0.053 | **0.063** | 0.077 | 0.096 |
| 71.1 | 110 | 1.40 | 0.03 | 0.041 | 0.047 | 0.054 | 0.064 | **0.076** | 0.092 | 0.114 |
| 77.5 | 120 | 1.53 | 0.04 | 0.048 | 0.055 | 0.064 | 0.075 | **0.089** | 0.108 | 0.134 |
| 90.5 | 140 | 1.78 | 0.05 | 0.064 | 0.073 | 0.085 | 0.100 | **0.118** | 0.144 | 0.179 |
| 103.4 | 160 | 2.04 | 0.06 | 0.082 | 0.094 | 0.108 | 0.127 | **0.152** | 0.184 | 0.229 |
| 116.3 | 180 | 2.29 | 0.08 | 0.102 | 0.116 | 0.134 | 0.158 | **0.188** | 0.229 | 0.284 |
| 129.3 | 200 | 2.55 | 0.10 | 0.123 | 0.141 | 0.163 | 0.192 | **0.229** | 0.279 | 0.348 |
| 142.2 | 220 | 2.80 | 0.12 | 0.147 | 0.168 | 0.195 | 0.229 | **0.273** | 0.332 | 0.413 |
| 155.1 | 240 | 3.06 | 0.15 | 0.172 | 0.197 | 0.229 | 0.269 | **0.321** | 0.390 | 0.485 |
| 168.0 | 260 | 3.31 | 0.17 | 0.200 | 0.229 | 0.267 | 0.312 | **0.372** | 0.452 | 0.56 |
| 181.0 | 280 | 3.56 | 0.20 | 0.228 | 0.263 | 0.305 | 0.359 | **0.428** | 0.52 | 0.65 |
| 193.9 | 300 | 3.82 | 0.23 | 0.260 | 0.298 | 0.347 | 0.407 | **0.484** | 0.59 | 0.74 |
| 206.8 | 320 | 4.07 | 0.26 | 0.293 | 0.337 | 0.390 | 0.459 | **0.55** | 0.66 | 0.83 |
| 219.7 | 340 | 4.33 | 0.29 | 0.328 | 0.377 | 0.438 | 0.51 | **0.61** | 0.74 | 0.92 |
| 232.7 | 360 | 4.58 | 0.33 | 0.364 | 0.418 | 0.485 | 0.57 | **0.68** | 0.82 | 1.03 |
| 245.6 | 380 | 4.84 | 0.36 | 0.402 | 0.462 | 0.54 | 0.63 | **0.75** | 0.92 | 1.14 |
| 258.5 | 400 | 5.09 | 0.40 | 0.442 | 0.51 | 0.59 | 0.69 | **0.82** | 1.00 | 1.25 |
| 271.5 | 420 | 5.35 | 0.44 | 0.484 | 0.56 | 0.64 | 0.76 | **0.90** | 1.10 | 1.37 |
| 284.4 | 440 | 5.60 | 0.49 | 0.53 | 0.61 | 0.70 | 0.83 | **0.98** | 1.19 | 1.49 |
| 297.3 | 460 | 5.86 | 0.53 | 0.57 | 0.66 | 0.76 | 0.90 | **1.07** | 1.30 | 1.62 |
| 310.2 | 480 | 6.11 | 0.58 | 0.62 | 0.71 | 0.83 | 0.97 | **1.16** | 1.42 | 1.76 |
| 323.2 | 500 | 6.37 | 0.63 | 0.67 | 0.77 | 0.90 | 1.04 | **1.25** | 1.52 | 1.88 |
| 355.5 | 550 | 7.00 | 0.76 | 0.80 | 0.92 | 1.07 | 1.25 | **1.48** | 1.82 | 2.26 |
| 387.8 | 600 | 7.64 | 0.91 | 0.94 | 1.08 | 1.25 | 1.47 | **1.75** | 2.13 | 2.65 |
| 420.1 | 650 | 8.27 | 1.06 | 1.08 | 1.25 | 1.45 | 1.71 | **2.04** | 2.48 | 3.07 |
| 452.4 | 700 | 8.91 | 1.23 | 1.25 | 1.43 | 1.67 | 1.96 | **2.33** | 2.83 | 3.52 |
| 484.7 | 750 | 9.55 | 1.42 | 1.42 | 1.63 | 1.88 | 2.22 | **2.64** | 3.22 | 4.00 |
| 517 | 800 | 10.18 | 1.61 | 1.59 | 1.83 | 2.12 | 2.49 | **2.98** | 3.62 | 4.50 |

| Discharge in: Million Gallons per 24 Hours. | Discharge in: Cubic Feet per Second. | Velocity in Feet per Second. | Velocity Head, Feet. | Extremely Smooth and Straight c=140 | Very Smooth c=130 | Good Masonry Aqueducts. c=120 | Riveted Steel Pipe, New. c=110 | Steel Pipe 10 Years Old, Brick Sewers. c=100 | Rough. c=90 | Very Rough. c=80 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Loss of Head in Feet per 1000 feet of length. | | | | | | |
| 19.39 | 30 | 0.32 | 0.00 | 0.002 | 0.003 | 0.003 | 0.004 | **0.004** | 0.005 | 0.006 |
| 25.85 | 40 | 0.42 | 0.00 | 0.004 | 0.005 | 0.005 | 0.006 | **0.007** | 0.009 | 0.011 |
| 32.32 | 50 | 0.53 | 0.00 | 0.006 | 0.007 | 0.008 | 0.009 | **0.011** | 0.013 | 0.017 |
| 38.78 | 60 | 0.63 | 0.01 | 0.009 | 0.010 | 0.011 | 0.013 | **0.016** | 0.019 | 0.024 |
| 51.7 | 80 | 0.84 | 0.01 | 0.014 | 0.016 | 0.019 | 0.022 | **0.026** | 0.032 | 0.040 |
| 64.6 | 100 | 1.05 | 0.02 | 0.021 | 0.025 | 0.028 | 0.034 | **0.040** | 0.048 | 0.060 |
| 77.5 | 120 | 1.26 | 0.02 | 0.030 | 0.035 | 0.040 | 0.047 | **0.056** | 0.068 | 0.085 |
| 90.5 | 140 | 1.47 | 0.03 | 0.040 | 0.046 | 0.054 | 0.063 | **0.075** | 0.091 | 0.113 |
| 103.4 | 160 | 1.68 | 0.04 | 0.052 | 0.059 | 0.068 | 0.080 | **0.096** | 0.117 | 0.145 |
| 116.3 | 180 | 1.89 | 0.06 | 0.064 | 0.073 | 0.085 | 0.100 | **0.119** | 0.144 | 0.180 |
| 129.3 | 200 | 2.10 | 0.07 | 0.078 | 0.089 | 0.103 | 0.122 | **0.144** | 0.176 | 0.218 |
| 142.2 | 220 | 2.31 | 0.08 | 0.092 | 0.107 | 0.123 | 0.144 | **0.172** | 0.208 | 0.260 |
| 155.1 | 240 | 2.52 | 0.10 | 0.108 | 0.124 | 0.144 | 0.169 | **0.202** | 0.246 | 0.307 |
| 168.0 | 260 | 2.74 | 0.12 | 0.126 | 0.144 | 0.167 | 0.196 | **0.234** | 0.285 | 0.354 |
| 181.0 | 280 | 2.95 | 0.13 | 0.144 | 0.166 | 0.192 | 0.226 | **0.268** | 0.327 | 0.407 |
| 193.9 | 300 | 3.16 | 0.15 | 0.164 | 0.188 | 0.219 | 0.257 | **0.305** | 0.371 | 0.462 |
| 206.8 | 320 | 3.37 | 0.18 | 0.184 | 0.211 | 0.246 | 0.289 | **0.344** | 0.419 | 0.52 |
| 219.7 | 340 | 3.58 | 0.20 | 0.207 | 0.238 | 0.276 | 0.322 | **0.386** | 0.469 | 0.58 |
| 232.7 | 360 | 3.79 | 0.22 | 0.230 | 0.262 | 0.306 | 0.359 | **0.429** | 0.52 | 0.65 |
| 245.6 | 380 | 4.00 | 0.25 | 0.254 | 0.291 | 0.339 | 0.398 | **0.472** | 0.58 | 0.72 |
| 258.5 | 400 | 4.20 | 0.27 | 0.279 | 0.320 | 0.372 | 0.437 | **0.52** | 0.63 | 0.79 |
| 271.5 | 420 | 4.42 | 0.30 | 0.306 | 0.351 | 0.407 | 0.478 | **0.57** | 0.69 | 0.86 |
| 284.4 | 440 | 4.62 | 0.33 | 0.332 | 0.382 | 0.442 | 0.52 | **0.62** | 0.76 | 0.94 |
| 297.3 | 460 | 4.84 | 0.36 | 0.361 | 0.415 | 0.481 | 0.56 | **0.68** | 0.82 | 1.02 |
| 310.2 | 480 | 5.05 | 0.40 | 0.391 | 0.449 | 0.52 | 0.61 | **0.73** | 0.89 | 1.11 |
| 323.2 | 500 | 5.26 | 0.43 | 0.421 | 0.483 | 0.56 | 0.66 | **0.79** | 0.96 | 1.18 |
| 355.5 | 550 | 5.79 | 0.52 | 0.50 | 0.58 | 0.67 | 0.79 | **0.94** | 1.14 | 1.42 |
| 387.8 | 600 | 6.30 | 0.62 | 0.59 | 0.68 | 0.78 | 0.92 | **1.11** | 1.34 | 1.67 |
| 420.1 | 650 | 6.84 | 0.73 | 0.68 | 0.78 | 0.92 | 1.07 | **1.28** | 1.56 | 1.93 |
| 452.4 | 700 | 7.36 | 0.84 | 0.79 | 0.90 | 1.05 | 1.23 | **1.47** | 1.78 | 2.22 |
| 484.7 | 750 | 7.89 | 0.97 | 0.90 | 1.03 | 1.18 | 1.39 | **1.67** | 2.03 | 2.52 |
| 517 | 800 | 8.42 | 1.10 | 1.01 | 1.16 | 1.34 | 1.58 | **1.88** | 2.29 | 2.84 |
| 549 | 850 | 8.94 | 1.24 | 1.13 | 1.29 | 1.50 | 1.77 | **2.10** | 2.56 | 3.19 |
| 582 | 900 | 9.47 | 1.39 | 1.26 | 1.44 | 1.67 | 1.96 | **2.33** | 2.84 | 3.54 |
| 614 | 950 | 9.99 | 1.55 | 1.38 | 1.59 | 1.84 | 2.17 | **2.59** | 3.13 | 3.90 |

| Discharge in | | Velocity in Feet per Second. | Velocity Head, Feet. | Loss of Head in Feet per 1000 feet of length. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Million Gallons per 24 Hours. | Cubic Feet per Second. | | | Extremely Smooth and Straight $c=140$ | Very Smooth $c=130$ | Good Masonry Aqueducts. $c=120$ | Riveted Steel Pipe, New. $c=110$ | Steel Pipe 10 Years Old, Brick Sewers. $c=100$ | Rough. $c=90$ | Very Rough. $c=80$ |
| 25.85 | 40 | 0.35 | 0.00 | 0.003 | 0.003 | 0.003 | 0.004 | **0.005** | 0.006 | 0.007 |
| 38.78 | 60 | 0.53 | 0.00 | 0.005 | 0.006 | 0.007 | 0.009 | **0.010** | 0.012 | 0.015 |
| 51.7 | 80 | 0.71 | 0.01 | 0.009 | 0.011 | 0.012 | 0.014 | **0.017** | 0.021 | 0.026 |
| 64.6 | 100 | 0.88 | 0.01 | 0.014 | 0.016 | 0.019 | 0.022 | **0.026** | 0.032 | 0.040 |
| 77.5 | 120 | 1.06 | 0.02 | 0.020 | 0.023 | 0.026 | 0.031 | **0.037** | 0.045 | 0.055 |
| 90.5 | 140 | 1.24 | 0.02 | 0.026 | 0.030 | 0.035 | 0.041 | **0.049** | 0.059 | 0.074 |
| 103.4 | 160 | 1.41 | 0.03 | 0.034 | 0.039 | 0.045 | 0.052 | **0.062** | 0.076 | 0.094 |
| 116.3 | 180 | 1.59 | 0.04 | 0.042 | 0.048 | 0.056 | 0.065 | **0.078** | 0.094 | 0.117 |
| 129.3 | 200 | 1.77 | 0.05 | 0.050 | 0.058 | 0.068 | 0.079 | **0.094** | 0.115 | 0.143 |
| 142.2 | 220 | 1.94 | 0.06 | 0.060 | 0.070 | 0.080 | 0.094 | **0.113** | 0.137 | 0.171 |
| 155.1 | 240 | 2.12 | 0.07 | 0.071 | 0.082 | 0.094 | 0.111 | **0.132** | 0.161 | 0.200 |
| 168.0 | 260 | 2.30 | 0.08 | 0.082 | 0.094 | 0.109 | 0.128 | **0.153** | 0.186 | 0.232 |
| 181.0 | 280 | 2.48 | 0.09 | 0.094 | 0.108 | 0.126 | 0.148 | **0.176** | 0.213 | 0.267 |
| 193.9 | 300 | 2.65 | 0.11 | 0.107 | 0.123 | 0.143 | 0.168 | **0.200** | 0.242 | 0.302 |
| 206.8 | 320 | 2.83 | 0.12 | 0.121 | 0.139 | 0.161 | 0.188 | **0.226** | 0.273 | 0.341 |
| 219.7 | 340 | 3.01 | 0.14 | 0.136 | 0.156 | 0.181 | 0.211 | **0.252** | 0.307 | 0.381 |
| 232.7 | 360 | 3.18 | 0.16 | 0.151 | 0.173 | 0.200 | 0.235 | **0.281** | 0.341 | 0.424 |
| 245.6 | 380 | 3.36 | 0.18 | 0.167 | 0.191 | 0.222 | 0.260 | **0.309** | 0.377 | 0.469 |
| 258.5 | 400 | 3.54 | 0.19 | 0.183 | 0.209 | 0.243 | 0.287 | **0.341** | 0.414 | 0.52 |
| 271.5 | 420 | 3.71 | 0.21 | 0.201 | 0.230 | 0.267 | 0.313 | **0.373** | 0.455 | 0.57 |
| 284.4 | 440 | 3.89 | 0.23 | 0.218 | 0.249 | 0.290 | 0.341 | **0.406** | 0.494 | 0.62 |
| 297.3 | 460 | 4.07 | 0.26 | 0.237 | 0.272 | 0.314 | 0.371 | **0.441** | 0.54 | 0.67 |
| 310.2 | 480 | 4.24 | 0.28 | 0.256 | 0.293 | 0.341 | 0.400 | **0.477** | 0.58 | 0.72 |
| 323.2 | 500 | 4.42 | 0.30 | 0.277 | 0.318 | 0.369 | 0.432 | **0.52** | 0.63 | 0.78 |
| 355.5 | 550 | 4.86 | 0.37 | 0.330 | 0.379 | 0.439 | 0.52 | **0.62** | 0.75 | 0.93 |
| 387.8 | 600 | 5.30 | 0.44 | 0.388 | 0.448 | 0.52 | 0.61 | **0.72** | 0.88 | 1.08 |
| 420.1 | 650 | 5.75 | 0.51 | 0.450 | 0.52 | 0.60 | 0.70 | **0.84** | 1.02 | 1.27 |
| 452.4 | 700 | 6.19 | 0.59 | 0.52 | 0.59 | 0.68 | 0.80 | **0.96** | 1.17 | 1.46 |
| 484.7 | 750 | 6.63 | 0.68 | 0.58 | 0.67 | 0.78 | 0.92 | **1.09** | 1.33 | 1.66 |
| 517 | 800 | 7.07 | 0.78 | 0.66 | 0.76 | 0.88 | 1.03 | **1.23** | 1.49 | 1.86 |
| 549 | 850 | 7.51 | 0.88 | 0.74 | 0.85 | 0.98 | 1.16 | **1.38** | 1.67 | 2.08 |
| 582 | 900 | 7.96 | 0.98 | 0.82 | 0.94 | 1.09 | 1.28 | **1.53** | 1.86 | 2.32 |
| 614 | 950 | 8.40 | 1.09 | 0.91 | 1.04 | 1.21 | 1.42 | **1.69** | 2.06 | 2.57 |
| 646 | 1000 | 8.84 | 1.21 | 1.00 | 1.14 | 1.33 | 1.56 | **1.86** | 2.27 | 2.82 |
| 711 | 1100 | 9.72 | 1.46 | 1.19 | 1.37 | 1.58 | 1.86 | **2.22** | 2.70 | 3.37 |

# RELATIVE DISCHARGING CAPACITIES OF AQUEDUCTS.




| | Relative Elements of Conduits when Flowing Full. | | | | At Approximate Point of Maximum Discharge. | | | |
|---|---|---|---|---|---|---|---|---|
| | Area. | Wetted Perimeter. | Mean Hydraulic Radius. | Velocity. | Area. | Wetted Perimeter. | Mean Hydraulic Radius. | Velocity |
| Circle | 1000 | 1000 | 1000 | 1000 | 975 | 841 | 1160 | 1098 |
| $r_1 = 1.5r$ | 1034 | 1023 | 1011 | 1007 | 1009 | 864 | 1168 | 1103 |
| $r_1 = 2.0r$ | 1057 | 1040 | 1018 | 1011 | 1032 | 881 | 1172 | 1106 |
| $r_1 = 2.5r$ | 1071 | 1054 | 1018 | 1011 | 1046 | 895 | 1169 | 1104 |
| $r_1 = 3r$ | 1078 | 1063 | 1016 | 1010 | 1053 | 904 | 1165 | 1101 |
| $r_1 = 4r$ | 1089 | 1076 | 1014 | 1009 | 1064 | 917 | 1160 | 1098 |
| $\frac{1}{2}$ square | 1136 | 1136 | 1000 | 1000 | 1111 | 977 | 1137 | 1083 |
| Square | 1273 | 1273 | 1000 | 1000 | 1273 | 955 | 1333 | 1199 |

# AQUEDUCTS,—8 TO 14 FEET.

$c = 125$. At point of maximum discharge the quantity is taken as 12% greater than in a circular aqueduct of the same height and width running full.

| Slope in Feet per 1000. | Slope in Feet per Mile. | 8′ | 9′ | 10′ | 11′ | 12′ | 13′ | 14′ |
|---|---|---|---|---|---|---|---|---|
| | | Discharge in Million Gallons Daily. | | | | | | |
| 0.030 | 0.158 | 34 | 46 | 60 | 78 | 98 | 120 | 146 |
| 0.035 | 0.185 | 36 | 50 | 66 | 84 | 106 | 130 | 159 |
| 0.040 | 0.211 | 39 | 53 | 71 | 91 | 114 | 140 | 171 |
| 0.045 | 0.238 | 42 | 57 | 75 | 97 | 121 | 150 | 182 |
| 0.050 | 0.264 | 44 | 60 | 79 | 102 | 128 | 158 | 192 |
| 0.055 | 0.290 | 46 | 63 | 84 | 108 | 135 | 167 | 203 |
| 0.060 | 0.317 | 49 | 66 | 88 | 112 | 142 | 175 | 212 |
| 0.065 | 0.343 | 51 | 69 | 91 | 118 | 148 | 182 | 221 |
| 0.070 | 0.370 | 53 | 72 | 95 | 122 | 154 | 190 | 231 |
| 0.080 | 0.422 | 57 | 78 | 102 | 132 | 166 | 205 | 248 |
| 0.090 | 0.475 | 61 | 83 | 109 | 140 | 176 | 218 | 265 |
| 0.10 | 0.528 | 64 | 88 | 116 | 148 | 186 | 230 | 280 |
| 0.11 | 0.581 | 68 | 92 | 122 | 156 | 196 | 242 | 295 |
| 0.12 | 0.634 | 71 | 97 | 127 | 164 | 205 | 254 | 309 |
| 0.14 | 0.739 | 77 | 105 | 138 | 178 | 224 | 276 | 336 |
| 0.16 | 0.845 | 83 | 113 | 149 | 192 | 240 | 297 | 361 |
| 0.18 | 0.950 | 88 | 120 | 159 | 204 | 256 | 316 | 385 |
| 0.20 | 1.056 | 93 | 127 | 168 | 215 | 271 | 335 | 407 |
| 0.22 | 1.162 | 98 | 134 | 177 | 227 | 285 | 352 | 428 |
| 0.24 | 1.267 | 103 | 140 | 185 | 239 | 300 | 370 | 450 |
| 0.26 | 1.373 | 108 | 147 | 194 | 249 | 313 | 386 | 469 |
| 0.28 | 1.478 | 112 | 153 | 201 | 259 | 325 | 402 | 488 |
| 0.30 | 1.584 | 116 | 159 | 209 | 269 | 338 | 418 | 508 |
| 0.35 | 1.848 | 126 | 172 | 227 | 291 | 366 | 453 | 550 |
| 0.40 | 2.112 | 136 | 185 | 244 | 314 | 395 | 487 | 591 |
| 0.45 | 2.376 | 145 | 197 | 260 | 335 | 420 | 519 | 631 |
| 0.50 | 2.640 | 153 | 209 | 275 | 354 | 445 | 549 | 668 |
| 0.55 | 2.904 | 162 | 219 | 290 | 373 | 468 | 579 | 701 |
| 0.60 | 3.168 | 169 | 230 | 304 | 390 | 490 | 606 | 736 |
| 0.65 | 3.432 | 177 | 240 | 317 | 407 | 511 | 631 | 770 |
| 0.70 | 3.696 | 184 | 250 | 330 | 424 | 533 | 659 | 800 |
| 0.80 | 4.224 | 197 | 269 | 355 | 456 | 573 | 709 | 860 |
| 0.90 | 4.752 | 210 | 287 | 378 | 485 | 610 | 754 | 918 |
| 1.00 | 5.28 | 223 | 304 | 400 | 514 | 647 | 800 | 970 |
| 1.10 | 5.81 | 235 | 319 | 421 | 541 | 680 | 840 | 1020 |

# AQUEDUCTS,—15 TO 21 FEET.

$c=125$. At point of maximum discharge the quantity is taken as 12% greater than in a circular aqueduct of the same height and width running full.

| Slope in Feet per 1000. | Slope in Feet per Mile. | 15′ | 16′ | 17′ | 18′ | 19′ | 20′ | 21′ |
|---|---|---|---|---|---|---|---|---|
| | | Discharge in Million Gallons Daily. | | | | | | |
| 0.020 | 0.106 | 140 | 167 | 196 | 228 | 263 | 300 | 341 |
| 0.022 | 0.116 | 148 | 176 | 205 | 239 | 276 | 316 | 358 |
| 0.024 | 0.127 | 155 | 184 | 215 | 250 | 289 | 330 | 376 |
| 0.026 | 0.137 | 162 | 192 | 227 | 261 | 303 | 346 | 392 |
| 0.028 | 0.148 | 169 | 200 | 237 | 274 | 315 | 360 | 410 |
| 0.030 | 0.158 | 176 | 208 | 245 | 285 | 326 | 374 | 426 |
| 0.035 | 0.185 | 190 | 226 | 266 | 310 | 355 | 406 | 460 |
| 0.040 | 0.211 | 205 | 243 | 286 | 330 | 381 | 437 | 495 |
| 0.045 | 0.238 | 218 | 258 | 305 | 352 | 406 | 465 | 528 |
| 0.050 | 0.264 | 232 | 274 | 323 | 372 | 430 | 493 | 560 |
| 0.055 | 0.290 | 243 | 288 | 340 | 395 | 453 | 518 | 588 |
| 0.060 | 0.317 | 254 | 300 | 353 | 410 | 475 | 542 | 617 |
| 0.065 | 0.343 | 266 | 315 | 372 | 433 | 495 | 569 | 642 |
| 0.070 | 0.370 | 277 | 328 | 388 | 450 | 516 | 591 | 670 |
| 0.080 | 0.422 | 298 | 353 | 410 | 480 | 552 | 635 | 720 |
| 0.09 | 0.475 | 317 | 376 | 440 | 510 | 591 | 670 | 770 |
| 0.10 | 0.528 | 336 | 398 | 470 | 542 | 625 | 718 | 810 |
| 0.11 | 0.581 | 354 | 420 | 490 | 570 | 660 | 750 | 860 |
| 0.12 | 0.634 | 370 | 439 | 510 | 600 | 690 | 790 | 900 |
| 0.14 | 0.739 | 404 | 477 | 562 | 650 | 750 | 860 | 980 |
| 0.16 | 0.845 | 432 | 512 | 600 | 700 | 810 | 920 | 1050 |
| 0.18 | 0.950 | 461 | 547 | 640 | 740 | 860 | 980 | 1120 |
| 0.20 | 1.056 | 488 | 579 | 680 | 790 | 910 | 1040 | 1180 |
| 0.22 | 1.162 | 513 | 610 | 710 | 830 | 960 | 1100 | 1240 |
| 0.24 | 1.267 | 540 | 640 | 750 | 870 | 1000 | 1150 | 1300 |
| 0.26 | 1.373 | 562 | 668 | 780 | 910 | 1050 | 1200 | 1360 |
| 0.28 | 1.478 | 585 | 694 | 810 | 940 | 1090 | 1250 | 1420 |
| 0.30 | 1.584 | 608 | 720 | 840 | 980 | 1130 | 1300 | 1470 |
| 0.35 | 1.848 | 660 | 780 | 915 | 1060 | 1230 | 1410 | 1600 |
| 0.40 | 2.112 | 710 | 841 | 990 | 1140 | 1320 | 1520 | 1720 |
| 0.45 | 2.376 | 758 | 896 | 1050 | 1220 | 1410 | 1620 | 1830 |
| 0.50 | 2.640 | 800 | 950 | 1110 | 1290 | 1490 | 1700 | 1940 |
| 0.55 | 2.904 | 842 | 1000 | 1170 | 1360 | 1570 | 1800 | 2040 |
| 0.60 | 3.168 | 885 | 1040 | 1230 | 1420 | 1650 | 1880 | 2130 |
| 0.65 | 3.432 | 921 | 1090 | 1280 | 1480 | 1720 | 1960 | 2230 |

## TABLE OF SLOPES REQUIRED TO PRODUCE GIVEN VELOCITIES.

Tile, $c=110$. Brick, $c=100$.

| Size. | Cubic Feet per Second. $v=1$ | $v=2$ | $v=2.5$ | $v=3$ | $v=4$ | $v=5$ | $v=7$ | $v=10$ |
|---|---|---|---|---|---|---|---|---|
| | | Slope in Feet per 1000. | | | | | | |
| 4″ Tile | 0.087 | 6.5 | 9.8 | 13.8 | 23.5 | 35.5 | 66.0 | 128 |
| 5″ " | 0.136 | 5.0 | 7.6 | 10.6 | 18.1 | 27.3 | 51.0 | 99 |
| 6″ " | 0.196 | 4.05 | 6.1 | 8.6 | 14.6 | 22.0 | 41.1 | 80 |
| 8″ " | 0.349 | 2.90 | 4.39 | 6.2 | 10.5 | 15.8 | 29.5 | 57 |
| 10″ " | 0.545 | 2.24 | 3.39 | 4.74 | 8.1 | 12.2 | 22.8 | 44 |
| 12″ " | 0.785 | 1.80 | 2.73 | 3.82 | 6.5 | 9.8 | 18.4 | 35.6 |
| 15″ " | 1.23 | 1.39 | 2.10 | 2.95 | 5.0 | 7.6 | 14.2 | 27.5 |
| 18″ " | 1.77 | 1.13 | 1.70 | 2.38 | 4.06 | 6.1 | 11.5 | 22.2 |
| 21″ " | 2.41 | 0.94 | 1.42 | 1.99 | 3.40 | 5.1 | 9.6 | 18.5 |
| 24″ " | 3.14 | 0.80 | 1.22 | 1.71 | 2.90 | 4.39 | 8.2 | 15.9 |
| 27″ " | 3.98 | 0.70 | 1.06 | 1.49 | 2.52 | 3.82 | 7.1 | 13.8 |
| 30″ " | 4.91 | 0.62 | 0.94 | 1.31 | 2.24 | 3.39 | 6.3 | 12.2 |
| 30″ Brick | 4.91 | 0.74 | 1.12 | 1.56 | 2.68 | 4.04 | 7.5 | 14.6 |
| 36″ " | 7.07 | 0.60 | 0.90 | 1.26 | 2.16 | 3.27 | 6.1 | 11.8 |
| 42″ " | 9.62 | 0.50 | 0.76 | 1.06 | 1.80 | 2.72 | 5.1 | 9.8 |
| 48″ " | 12.57 | 0.428 | 0.64 | 0.91 | 1.54 | 2.33 | 4.34 | 8.4 |
| 54″ " | 15.9 | 0.372 | 0.56 | 0.79 | 1.34 | 2.03 | 3.79 | 7.4 |
| 60″ " | 19.6 | 0.330 | 0.50 | 0.70 | 1.19 | 1.80 | 3.35 | 6.5 |
| 66″ " | 23.8 | 0.295 | 0.445 | 0.62 | 1.06 | 1.61 | 3.00 | 5.8 |
| 72″ " | 28.3 | 0.267 | 0.402 | 0.56 | 0.96 | 1.45 | 2.71 | 5.3 |
| 78″ " | 33.2 | 0.242 | 0.367 | 0.52 | 0.88 | 1.32 | 2.47 | 4.78 |
| 84″ " | 38.5 | 0.222 | 0.333 | 0.471 | 0.80 | 1.21 | 2.26 | 4.39 |
| 90″ " | 44.2 | 0.205 | 0.310 | 0.434 | 0.74 | 1.12 | 2.09 | 4.04 |
| 96″ " | 50.3 | 0.190 | 0.288 | 0.403 | 0.69 | 1.04 | 1.94 | 3.75 |
| 108″ " | 63.6 | 0.166 | 0.251 | 0.372 | 0.60 | 0.90 | 1.69 | 3.28 |
| 10′ " | 78.5 | 0.147 | 0.221 | 0.311 | 0.53 | 0.80 | 1.49 | 2.90 |
| 11′ " | 95.0 | 0.131 | 0.199 | 0.278 | 0.472 | 0.72 | 1.33 | 2.59 |
| 12′ " | 113 | 0.119 | 0.179 | 0.251 | 0.428 | 0.65 | 1.21 | 2.34 |
| 13′ " | 133 | 0.108 | 0.163 | 0.229 | 0.390 | 0.59 | 1.10 | 2.13 |
| 14′ " | 154 | 0.099 | 0.150 | 0.210 | 0.358 | 0.54 | 1.01 | 1.95 |
| 15′ " | 177 | 0.091 | 0.138 | 0.194 | 0.330 | 0.50 | 0.93 | 1.80 |
| 16′ " | 201 | 0.085 | 0.128 | 0.180 | 0.306 | 0.462 | 0.86 | 1.67 |
| 17′ " | 227 | 0.079 | 0.119 | 0.167 | 0.285 | 0.430 | 0.80 | 1.55 |
| 18′ " | 254 | 0.074 | 0.111 | 0.156 | 0.266 | 0.403 | 0.75 | 1.45 |
| 20′ " | 314 | 0.065 | 0.099 | 0.138 | 0.236 | 0.356 | 0.66 | 1.29 |

# TILE SEWERS,—4 TO 12 INCHES.

$c = 110.$

| Slope in Feet per 1000. | 4″ | 5″ | 6″ | 8″ | 10″ | 12″ |
|---|---|---|---|---|---|---|
| | Discharge in Cubic Feet per Second, Running Full. | | | | | |
| 1.8 | .... | .... | .... | .... | .... | *1.57* |
| 2.0 | .... | .... | .... | .... | .... | *1.66* |
| 2.2 | .... | .... | .... | .... | .... | *1.75* |
| 2.4 | .... | .... | .... | .... | *1.13* | *1.83* |
| 2.6 | .... | .... | .... | .... | *1.18* | *1.91* |
| 2.8 | .... | .... | .... | .... | *1.23* | *1.99* |
| 3.0 | .... | .... | .... | *0.71* | *1.28* | *2.06* |
| 3.5 | .... | .... | .... | *0.77* | *1.39* | *2.24* |
| 4.0 | .... | .... | *0.39* | *0.83* | *1.49* | 2.41 |
| 4.5 | .... | .... | *0.41* | *0.88* | *1.59* | 2.56 |
| 5 | .... | *0.27* | *0.44* | *0.94* | 1.68 | 2.72 |
| 6 | .... | *0.30* | *0.48* | *1.03* | 1.86 | 3.00 |
| 7 | *0.18* | *0.33* | *0.53* | 1.12 | 2.02 | 3.26 |
| 8 | *0.19* | *0.35* | *0.57* | 1.20 | 2.17 | 3.50 |
| 9 | *0.21* | *0.37* | 0.60 | 1.28 | 2.31 | 3.74 |
| 10 | *0.22* | *0.40* | 0.64 | 1.36 | 2.45 | 3.95 |
| 12 | *0.24* | 0.44 | 0.71 | 1.50 | 2.70 | 4.36 |
| 14 | 0.26 | 0.47 | 0.77 | 1.63 | 2.94 | 4.75 |
| 16 | 0.28 | 0.51 | 0.82 | 1.76 | 3.15 | 5.1 |
| 18 | 0.30 | 0.54 | 0.88 | 1.87 | 3.36 | 5.4 |
| 20 | 0.32 | 0.58 | 0.93 | 1.98 | 3.56 | 5.8 |
| 22 | 0.34 | 0.60 | 0.98 | 2.09 | 3.75 | 6.1 |
| 24 | 0.35 | 0.64 | 1.03 | 2.19 | 3.94 | 6.4 |
| 26 | 0.37 | 0.66 | 1.07 | 2.28 | 4.10 | 6.6 |
| 28 | 0.38 | 0.69 | 1.11 | 2.38 | 4.28 | 6.9 |
| 30 | 0.40 | 0.72 | 1.15 | 2.46 | 4.43 | 7.2 |
| 35 | 0.43 | 0.78 | 1.26 | 2.68 | 4.83 | 7.8 |
| 40 | 0.46 | 0.84 | 1.35 | 2.88 | 5.2 | *8.4* |
| 45 | 0.49 | 0.89 | 1.44 | 3.07 | *5.5* | *8.9* |
| 50 | 0.52 | 0.94 | 1.52 | 3.25 | *5.8* | *9.4* |
| 60 | 0.58 | 1.04 | 1.68 | *3.58* | *6.4* | *10.4* |
| 70 | 0.63 | 1.13 | 1.83 | *3.90* | *7.0* | *11.3* |
| 80 | 0.67 | 1.21 | 1.96 | *4.18* | *7.5* | *12.1* |
| 90 | 0.72 | 1.30 | *2.10* | *4.46* | *8.0* | *12.9* |
| 100 | 0.76 | *1.37* | *2.22* | *4.73* | *8.5* | *13.7* |

Quantities corresponding to velocities between 2 and 3 and over 10 feet per second are in italics

# TILE SEWERS,—15 TO 36 INCHES.

$c = 110.$

| Slope in Feet per 1000. | 15″ | 18″ | 21″ | 24″ | 27″ | 30″ | 36″ |
|---|---|---|---|---|---|---|---|
| | Discharge in Cubic Feet per Second, Running Full. | | | | | | |
| 0.5 | .... | .... | .... | .... | .... | .... | *14.1* |
| 0.6 | .... | .... | .... | .... | .... | .... | *15.6* |
| 0.7 | .... | .... | .... | .... | *7.9* | *10.5* | *16.9* |
| 0.8 | .... | .... | .... | *6.3* | *8.5* | *11.3* | *18.2* |
| 0.9 | .... | .... | .... | *6.7* | *9.1* | *12.0* | *19.4* |
| 1.0 | .... | .... | *5.0* | *7.1* | *9.6* | *12.7* | *20.5* |
| 1.2 | .... | *3.7* | *5.5* | *7.8* | *10.6* | *14.0* | 22.6 |
| 1.4 | *2.5* | *4.0* | *6.0* | *8.5* | *11.5* | 15.2 | 24.6 |
| 1.6 | *2.6* | *4.3* | *6.4* | *9.1* | 12.4 | 16.4 | 26.5 |
| 1.8 | *2.8* | *4.5* | *6.8* | 9.7 | 13.2 | 17.4 | 28.2 |
| 2.0 | *3.0* | *4.8* | 7.2 | 10.3 | 14.0 | 18.4 | 29.8 |
| 2.2 | *3.1* | *5.1* | 7.6 | 10.8 | 14.7 | 19.4 | 31.4 |
| 2.4 | *3.3* | 5.3 | 8.0 | 11.4 | 15.4 | 20.4 | 32.9 |
| 2.6 | *3.4* | 5.5 | 8.3 | 11.8 | 16.1 | 21.2 | 34.4 |
| 2.8 | *3.6* | 5.8 | 8.7 | 12.3 | 16.8 | 22.1 | 35.7 |
| 3.0 | 3.7 | 6.0 | 9.0 | 12.8 | 17.4 | 23.0 | 37.1 |
| 3.5 | 4.0 | 6.5 | 9.8 | 13.9 | 18.9 | 25.0 | 40.3 |
| 4.0 | 4.3 | 7.0 | 10.5 | 14.9 | 20.4 | 26.9 | 43.4 |
| 4.5 | 4.6 | 7.5 | 11.2 | 15.9 | 21.6 | 28.6 | 46.2 |
| 5.0 | 4.9 | 7.9 | 11.9 | 16.8 | 23.0 | 30.3 | 48.9 |
| 6 | 5.4 | 8.7 | 13.1 | 18.6 | 25.4 | 33.4 | 54 |
| 7 | 5.9 | 9.5 | 14.2 | 20.2 | 27.5 | 36.4 | 59 |
| 8 | 6.3 | 10.2 | 15.3 | 21.7 | 29.6 | 39.0 | 63 |
| 9 | 6.7 | 10.9 | 16.3 | 23.1 | 31.5 | 41.6 | 67 |
| 10 | 7.1 | 11.5 | 17.2 | 24.5 | 33.4 | 44.0 | *71* |
| 12 | 7.8 | 12.7 | 19.0 | 27.0 | 36.8 | 48.6 | *78* |
| 14 | 8.5 | 13.8 | 20.6 | 29.4 | *40.0* | *53* | *85* |
| 16 | 9.1 | 14.8 | 22.2 | *31.5* | *43.0* | *57* | *92* |
| 18 | 9.7 | 15.8 | 23.6 | *33.6* | *45.8* | *60* | *98* |
| 20 | 10.3 | 16.7 | *25.0* | *35.6* | *48.5* | *64* | *103* |
| 22 | 10.9 | 17.6 | *26.4* | *37.5* | *51* | *67* | *109* |
| 24 | 11.4 | *18.4* | *27.6* | *39.3* | *53* | *71* | *114* |
| 26 | 11.9 | *19.2* | *28.9* | *41.0* | *56* | *74* | *119* |
| 28 | *12.4* | *20.0* | *30.0* | *42.7* | *58* | *77* | *124* |
| 30 | *12.8* | *20.8* | *31.1* | *44.2* | *60* | *80* | *128* |

Quantities corresponding to velocities between 2 and 3 and over 10 feet per second are in italics.

# BRICK SEWERS,—30 TO 66 INCHES.

$c = 100.$

| Slope in Feet per 1000. | 30″ | 36″ | 42″ | 48″ | 54″ | 60″ | 66″ |
|---|---|---|---|---|---|---|---|
| | Discharge in Cubic Feet per Second, Running Full. | | | | | | |
| 0.30 | .... | .... | ..... | ... | ... | ... | *48* |
| 0.35 | .... | .... | ..... | ... | ... | *41* | *52* |
| 0.40 | .... | .... | ..... | ... | *33* | *44* | *56* |
| 0.45 | .... | .... | ..... | *26* | *35* | *46* | *60* |
| 0.50 | .... | .... | *19.3* | *27* | *37* | *49* | *63* |
| 0.55 | .... | .... | *20.3* | *29* | *39* | *52* | *67* |
| 0.60 | .... | *14.2* | *21.2* | *30* | *41* | *54* | *70* |
| 0.65 | .... | *14.8* | *22.2* | *32* | *43* | *57* | 73 |
| 0.70 | ... | *15.4* | *23.1* | *33* | *45* | *59* | 76 |
| 0.80 | *10.2* | *16.6* | *24.8* | *35* | 48 | 63 | 82 |
| 0.9 | *10.9* | *17.6* | *26.5* | *38* | 51 | 68 | 87 |
| 1.0 | *11.6* | *18.7* | *28.0* | 40 | 54 | 71 | 92 |
| 1.1 | *12.2* | *19.7* | 29.5 | 42 | 57 | 75 | 97 |
| 1.2 | *12.8* | *20.6* | 30.9 | 44 | 60 | 79 | 101 |
| 1.4 | *13.9* | 22.4 | 33.5 | 48 | 65 | 86 | 110 |
| 1.6 | 14.9 | 24.0 | 36.0 | 51 | 70 | 92 | 118 |
| 1.8 | 15.9 | 25.6 | 38.4 | 55 | 74 | 98 | 126 |
| 2.0 | 16.8 | 27.1 | 40.6 | 58 | 79 | 104 | 134 |
| 2.2 | 17.7 | 28.6 | 42.9 | 61 | 83 | 110 | 141 |
| 2.4 | 18.5 | 29.9 | 44.9 | 64 | 87 | 115 | 147 |
| 2.6 | 19.3 | 31.2 | 46.8 | 66 | 91 | 120 | 154 |
| 2.8 | 20.1 | 32.5 | 48.8 | 69 | 94 | 125 | 160 |
| 3.0 | 20.9 | 33.8 | 51 | 72 | 98 | 130 | 166 |
| 3.5 | 22.7 | 36.7 | 55 | 78 | 107 | *141* | *181* |
| 4.0 | 24.4 | 39.5 | 59 | 84 | *114* | *151* | *194* |
| 4.5 | 26.0 | 42.0 | 63 | *90* | *122* | *161* | *207* |
| 5.0 | 27.5 | 44.5 | 67 | *95* | *129* | *170* | *219* |
| 5.5 | 29.0 | 47 | *70* | *100* | *136* | *180* | *231* |
| 6.0 | 30.4 | 49 | *74* | *105* | *143* | *188* | *241* |
| 6.5 | 31.8 | *51* | *77* | *109* | *149* | *197* | *253* |
| 7 | 33.0 | *53* | *80* | *114* | *155* | *205* | *263* |
| 8 | *35.5* | *57* | *86* | *122* | *166* | *220* | *282* |
| 9 | *37.8* | *61* | *92* | *130* | *178* | *234* | *301* |
| 10 | *40.0* | *65* | *97* | *138* | *188* | *248* | *319* |
| 11 | *42.1* | *68* | *102* | *145* | *198* | *261* | *335* |

Quantities corresponding to velocities between 2 and 3 and over 7 feet per second are in italics.

# BRICK SEWERS,—72 TO 108 INCHES.

$c = 100.$

| Slope in Feet per 1000. | 72″ | 78″ | 84″ | 90″ | 96″ | 108″ |
|---|---|---|---|---|---|---|
| | Discharge in Cubic Feet per Second, Running Full. | | | | | |
| 0.18 | .... | .... | .... | .... | .... | *133* |
| 0.20 | .... | .... | .... | .... | *103* | *141* |
| 0.22 | .... | .... | *77* | *92* | *109* | *148* |
| 0.24 | .... | *66* | *80* | *97* | *114* | *156* |
| 0.26 | .... | *69* | *84* | *101* | *119* | *162* |
| 0.28 | *58* | *72* | *87* | *105* | *124* | *169* |
| 0.30 | *60* | *74* | *91* | *109* | *129* | *175* |
| 0.32 | *62* | *77* | *94* | *113* | *133* | *182* |
| 0.34 | *65* | *80* | *97* | *116* | *138* | *188* |
| 0.36 | *66* | *82* | *100* | *120* | *142* | 194 |
| 0.38 | *69* | *85* | *103* | *124* | *146* | 199 |
| 0.40 | *71* | *87* | *106* | *127* | *150* | 205 |
| 0.45 | *75* | *93* | *113* | 136 | 160 | 218 |
| 0.50 | *79* | *98* | 119 | 144 | 169 | 230 |
| 0.55 | *84* | 103 | 126 | 151 | 178 | 243 |
| 0.60 | 88 | 108 | 132 | 158 | 187 | 255 |
| 0.65 | 92 | 113 | 138 | 166 | 196 | 266 |
| 0.70 | 95 | 118 | 143 | 172 | 203 | 277 |
| 0.75 | 99 | 122 | 149 | 179 | 211 | 288 |
| 0.8 | 102 | 126 | 154 | 185 | 218 | 298 |
| 0.9 | 109 | 135 | 164 | 197 | 233 | 316 |
| 1.0 | 116 | 143 | 173 | 207 | 246 | 335 |
| 1.1 | 122 | 150 | 182 | 220 | 259 | 353 |
| 1.2 | 128 | 158 | 192 | 230 | 272 | 370 |
| 1.3 | 133 | 164 | 200 | 240 | 284 | 386 |
| 1.4 | 139 | 171 | 208 | 250 | 295 | 402 |
| 1.5 | 144 | 178 | 216 | 260 | 306 | 418 |
| 1.6 | 149 | 184 | 224 | 269 | 317 | 433 |
| 1.8 | 159 | 196 | 238 | 287 | 338 | *460* |
| 2.0 | 168 | 207 | 252 | 304 | *357* | *488* |
| 2.2 | 176 | 218 | 265 | *319* | *376* | *510* |
| 2.4 | 185 | 229 | *278* | *335* | *395* | *540* |
| 2.6 | 194 | *239* | *290* | *349* | *412* | *560* |
| 2.8 | *201* | *249* | *302* | *364* | *429* | *570* |
| 3.0 | *209* | *258* | *314* | *378* | *446* | *610* |

Quantities corresponding to velocities between 2 and 3 and over 7 feet per second are in italics.

# BRICK SEWERS,—10 TO 15 FEET.

$c = 100.$

| Slope in Feet per 1000. | 10′ | 11′ | 12′ | 13′ | 14′ | 15′ |
|---|---|---|---|---|---|---|
| | Discharge in Cubic Feet per Second, Running Full. | | | | | |
| 0.09 | .... | .... | .... | .... | .... | *350* |
| 0.10 | .... | .... | .... | .... | *310* | *372* |
| 0.11 | .... | .... | .... | *268* | *326* | *391* |
| 0.12 | .... | .... | *228* | *281* | *341* | *410* |
| 0.13 | .... | .... | *238* | *294* | *356* | *428* |
| 0.14 | .... | *197* | *248* | *305* | *371* | *445* |
| 0.15 | *159* | *205* | *257* | *318* | *385* | *462* |
| 0.16 | *165* | *211* | *266* | *329* | *400* | *479* |
| 0.18 | *176* | *225* | *284* | *350* | *425* | *510* |
| 0.20 | *186* | *239* | *300* | *370* | *450* | 540 |
| 0.22 | *196* | *251* | *316* | *390* | 474 | 570 |
| 0.24 | *205* | *263* | *331* | 409 | 496 | 600 |
| 0.26 | *214* | *275* | 346 | 426 | 520 | 620 |
| 0.28 | *222* | 286 | 360 | 444 | 540 | 650 |
| 0.30 | *231* | 297 | 374 | 461 | 560 | 670 |
| 0.32 | 240 | 307 | 387 | 477 | 580 | 700 |
| 0.34 | 247 | 318 | 400 | 494 | 600 | 720 |
| 0.36 | 255 | 328 | 412 | 510 | 620 | 740 |
| 0.38 | 262 | 337 | 425 | 520 | 640 | 760 |
| 0.40 | 270 | 347 | 436 | 540 | 650 | 780 |
| 0.45 | 288 | 370 | 465 | 570 | 700 | 840 |
| 0.50 | 305 | 391 | 492 | 610 | 740 | 890 |
| 0.55 | 321 | 412 | 520 | 640 | 780 | 930 |
| 0.60 | 336 | 432 | 540 | 670 | 810 | 980 |
| 0.65 | 351 | 451 | 570 | 700 | 850 | 1020 |
| 0.70 | 365 | 470 | 590 | 730 | 890 | 1060 |
| 0.75 | 380 | 488 | 610 | 760 | 920 | 1100 |
| 0.8 | 392 | 500 | 630 | 780 | 950 | 1140 |
| 0.9 | 418 | 540 | 680 | 830 | 1010 | 1220 |
| 1.0 | 443 | 570 | 720 | 880 | 1070 | *1290* |
| 1.1 | 466 | 600 | 750 | 930 | *1130* | *1360* |
| 1.2 | 488 | 630 | 790 | *980* | *1180* | *1420* |
| 1.3 | 510 | 660 | *820* | *1020* | *1240* | *1480* |
| 1.4 | 530 | *680* | *860* | *1060* | *1290* | *1540* |
| 1.5 | *550* | *710* | *890* | *1100* | *1340* | *1600* |

Quantities corresponding to velocities between 2 and 3 and over 7 feet per second are in italics.

## COMPUTATION OF DECREASE IN THE VALUE OF *c* IN CAST-IRON PIPE, WITH AVERAGE SOFT UNFILTERED RIVER WATER, THROUGH A PERIOD OF YEARS.

1st. Assume that the original value of *c* is 130.

2d. Assume that the increase in loss of head due to tuberculation, etc., amounts to 3% per year.

3d. Assume that the diameter of the pipe is reduced by tuberculation at the rate of 0.01 inch per year, and that the value of *c* must be modified to correct for this.

| Age of Pipe in Years. | Value of *c*, with no Allowance for Reduction in Diameter. | 4″ | 6″ | 8″ | 10″ | 12″ | 16″ | 20″ | 24″ | 30″ | 36″ | 48″ | 60″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Value of *c* after Making Allowance for Decrease in Diameter. | | | | | | | | | | | |
| 0 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 |
| 10 | 113 | 106 | 108 | 109 | 110 | 110 | 111 | 111 | 112 | 112 | 112 | 112 | 112 |
| 20 | 101 | 88 | 92 | 94 | 96 | 97 | 98 | 99 | 99 | 99 | 99 | 100 | 100 |
| 30 | 92 | 75 | 80 | 83 | 85 | 86 | 87 | 88 | 89 | 90 | 90 | 90 | 91 |
| 40 | 85 | 64 | 71 | 74 | 76 | 78 | 79 | 80 | 81 | 82 | 83 | 83 | 84 |
| 50 | 79.3 | 56 | 63 | 67 | 69 | 71 | 73 | 74 | 75 | 76 | 76 | 77 | 78 |
| 60 | 74.6 | 48 | 56 | 61 | 63 | 65 | 67 | 69 | 70 | 71 | 71 | 72 | 73 |
| 70 | 70.6 | 42 | 51 | 55 | 58 | 60 | 62 | 64 | 65 | 66 | 67 | 67 | 68 |
| 80 | 67.1 | 37 | 46 | 51 | 54 | 56 | 58 | 60 | 61 | 62 | 63 | 64 | 65 |
| 90 | 64.2 | 33 | 42 | 47 | 50 | 52 | 55 | 57 | 58 | 59 | 60 | 61 | 62 |
| 100 | 61.5 | 29 | 38 | 43 | 47 | 49 | 52 | 54 | 55 | 56 | 57 | 58 | 59 |

## COMPARISON OF THE LOSS OF HEAD OF WATER IN PIPES OF VARIOUS AGES, AS COMPUTED BY THE METHODS USED

(1) by Coffin: "Graphical Solution of Hydraulic Problems."

(2) by Weston: "Friction of Water in Pipes."

(3) by Hazen & Williams: Figures used in this volume.

| Age of Pipe in Years. | Diameter of Pipe in Inches. | Velocity of 1 Foot per Second. | | | Velocity of 3 Feet per Second. | | | Velocity of 5 Feet per Second. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Coffin. | Weston | Hazen & Williams. | Coffin. | Weston | Hazen & Williams. | Coffin. | Weston | Hazen & Williams. |
| New | 4 | 1.55 | 1.18 | 1.32 | 11.7 | 10.4 | 10.2 | 30.0 | 29.0 | 26.0 |
| " | 16 | 0.28 | 0.25 | 0.26 | 2.09 | 2.20 | 2.00 | 5.3 | 6.2 | 5.2 |
| " | 48 | 0.067 | 0.080 | 0.072 | 0.51 | 0.71 | 0.55 | 1.3 | 2.0 | 1.4 |
| 10 | 4 | 1.88 | 1.54 | 1.90 | 16.0 | 13.6 | 15.0 | 44.0 | 38.0 | 38.0 |
| " | 16 | 0.34 | 0.33 | 0.35 | 2.9 | 2.9 | 2.7 | 7.8 | 8.1 | 7.0 |
| " | 48 | 0.08 | 0.10 | 0.10 | 0.7 | 0.9 | 0.7 | 1.9 | 2.6 | 1.9 |
| 20 | 4 | 2.30 | 1.90 | 2.70 | 21.0 | 17.0 | 21.0 | 61.0 | 47.0 | 53.0 |
| " | 16 | 0.41 | 0.41 | 0.44 | 3.8 | 3.6 | 3.4 | 11.0 | 10.0 | 9.0 |
| " | 48 | 0.10 | 0.13 | 0.12 | 0.9 | 1.2 | 0.9 | 2.6 | 3.2 | 2.3 |
| 40 | 4 | 3.10 | 2.60 | 4.90 | 31.0 | 23.0 | 38.0 | 96.0 | 65.0 | 96.0 |
| " | 16 | 0.55 | 0.56 | 0.65 | 5.6 | 5.0 | 5.0 | 17.0 | 14.0 | 13.0 |
| " | 48 | 0.13 | 0.18 | 0.17 | 1.4 | 1.6 | 1.3 | 4.2 | 4.4 | 3.3 |

# SHORT METRIC EQUIVALENT PIPE TABLE.

| Discharge in | | | Loss of Head in Meters per 1000 meters of length. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gallons Daily. | Cubic Meters Daily. | | Diameters in Meters. | | | | | | | | |
| $c=100$ Old. | $c=100$ Old. | $c=130$ New. | $D=0.1$ $=3.94$ Ins. | $D=0.2$ $=7.87$ Ins. | $D=0.3$ $=11.81$ Ins. | $D=0.4$ $=15.75$ Ins. | $D=0.5$ $=19.68$ Ins. | $D=0.6$ $=23.62$ Ins. | $D=0.8$ $=31.50$ Ins. | $D=1.0$ $=39.37$ Ins. | $D=1.2$ $=47.24$ Ins. |
| 26,417 | 100 | 130 | 0.6 | 0.02 | | | | | | | |
| 39,626 | 150 | 195 | 1.2 | 0.04 | | | | | | | |
| 52,834 | 200 | 260 | 2.0 | 0.07 | 0.01 | | | | | | |
| 66,042 | 250 | 325 | 3.1 | 0.11 | 0.01 | | | | | | |
| 79,251 | 300 | 390 | 4.3 | 0.15 | 0.02 | | | | | | |
| 92,459 | 350 | 455 | 5.8 | 0.20 | 0.03 | | | | | | |
| 105,668 | 400 | 520 | 7.4 | 0.25 | 0.03 | 0.01 | | | | | |
| 132,085 | 500 | 650 | 11.2 | 0.38 | 0.05 | 0.01 | | | | | |
| 158,502 | 600 | 780 | 15.6 | 0.54 | 0.07 | 0.02 | 0.01 | | | | |
| 211,336 | 800 | 1,040 | 26.6 | 0.91 | 0.13 | 0.03 | 0.01 | | | | |
| 264,170 | 1,000 | 1,300 | 40.5 | 1.38 | 0.19 | 0.05 | 0.02 | 0.01 | | | |
| 317,004 | 1,200 | 1,560 | 57 | 1.93 | 0.27 | 0.07 | 0.02 | 0.01 | | | |
| 369,838 | 1,400 | 1,820 | 76 | 2.58 | 0.36 | 0.09 | 0.03 | 0.01 | | | |
| 422,672 | 1,600 | 2,080 | 97 | 3.30 | 0.46 | 0.11 | 0.04 | 0.02 | | | |
| 475,506 | 1,800 | 2,340 | 120 | 4.10 | 0.57 | 0.14 | 0.05 | 0.02 | | | |
| 528,340 | 2,000 | 2,600 | 146 | 5.0 | 0.69 | 0.17 | 0.06 | 0.02 | | | |
| 660,425 | 2,500 | 3,250 | 220 | 7.5 | 1.05 | 0.26 | 0.09 | 0.04 | | | |
| 792,510 | 3,000 | 3,900 | 310 | 10.6 | 1.47 | 0.36 | 0.12 | 0.05 | 0.01 | | |
| 1,056,680 | 4,000 | 5,200 | 515 | 18.0 | 2.50 | 0.62 | 0.21 | 0.09 | 0.02 | 0.01 | |
| 1,320,850 | 5,000 | 6,500 | 800 | 27.2 | 3.80 | 0.93 | 0.31 | 0.13 | 0.03 | 0.01 | |
| 1,585,020 | 6,000 | 7,800 | ..... | 38 | 5.3 | 1.31 | 0.44 | 0.18 | 0.04 | 0.02 | 0.01 |
| 2,113,360 | 8,000 | 10,400 | ..... | 65 | 9.1 | 2.23 | 0.75 | 0.31 | 0.08 | 0.03 | 0.01 |
| 2,641,700 | 10,000 | 13,000 | ..... | 99 | 13.7 | 3.38 | 1.13 | 0.47 | 0.12 | 0.04 | 0.02 |
| 3,170,040 | 12,000 | 15,600 | ..... | 138 | 19.2 | 4.70 | 1.60 | 0.65 | 0.16 | 0.05 | 0.02 |
| 3,698,380 | 14,000 | 18,200 | ..... | 183 | 25.6 | 6.3 | 2.10 | 0.87 | 0.22 | 0.07 | 0.03 |
| 4,226,720 | 16,000 | 20,800 | ..... | 235 | 32.8 | 8.0 | 2.70 | 1.12 | 0.28 | 0.09 | 0.04 |
| 4,755,060 | 18,000 | 23,400 | ..... | 292 | 41.8 | 10.0 | 3.40 | 1.38 | 0.34 | 0.12 | 0.05 |
| 5,283,400 | 20,000 | 26,000 | ..... | 356 | 50 | 12.2 | 4.10 | 1.68 | 0.42 | 0.14 | 0.06 |
| 6,604,250 | 25,000 | 32,500 | ..... | ...... | 75 | 18.4 | 6.2 | 2.55 | 0.63 | 0.21 | 0.09 |
| 7,925,100 | 30,000 | 39,000 | ..... | ...... | 105 | 25.8 | 8.7 | 3.55 | 0.88 | 0.29 | 0.12 |
| 10,566,800 | 40,000 | 52,000 | ..... | ...... | 180 | 43 | 14.8 | 6.1 | 1.50 | 0.50 | 0.21 |
| 13,208,500 | 50,000 | 65,000 | ..... | ...... | 272 | 67 | 22.4 | 9.2 | 2.26 | 0.76 | 0.31 |
| 15,850,200 | 60,000 | 78,000 | ..... | ...... | ...... | 93 | 31.5 | 12.8 | 3.20 | 1.07 | 0.44 |
| 21,133,600 | 80,000 | 104,000 | ..... | ...... | ...... | 160 | 53 | 22.0 | 5.4 | 1.80 | 0.75 |
| 26,417,000 | 100,000 | 130 000 | ..... | ...... | ...... | 240 | 81 | 33.0 | 8.2 | 2.73 | 1.13 |

# VENTURI METERS.

TABLE SHOWING HEAD LOST IN EXCESS OF THAT LOST IN STRAIGHT PIPE, EXPRESSED IN TERMS OF THE VELOCITY HEAD IN THE PIPE.

*Note.*—The velocity head for any given discharge and pipe size may be found in the pipe tables.

| Diameter of Throat, Inches. | Diameter of Pipe. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10″ | 12″ | 16″ | 20″ | 24″ | 30″ | 36″ | 42″ | 48″ | 54″ | 60″ | 66″ | 72″ | 78″ | 84″ |
| | Loss of Head in Terms of Velocity Head. | | | | | | | | | | | | | | |
| 4 | 6 | 12 | 39 | | | | | | | | | | | | |
| 4.5 | 4 | 7 | 20 | | | | | | | | | | | | |
| 5 | 2 | 5 | 15 | 38 | | | | | | | | | | | |
| 5.5 | .... | 3 | 10 | 25 | | | | | | | | | | | |
| 6 | .... | 2 | 7 | 18 | 37 | | | | | | | | | | |
| 6.5 | .... | .... | 5 | 13 | 26 | | | | | | | | | | |
| 7 | .... | .... | 4 | 10 | 20 | | | | | | | | | | |
| 7.5 | .... | .... | 3 | 7 | 15 | 36 | | | | | | | | | |
| 8 | .... | .... | 2 | 5 | 11 | 28 | | | | | | | | | |
| 8.5 | .... | .... | .... | 4 | 9 | 22 | | | | | | | | | |
| 9 | .... | .... | .... | 3 | 7 | 17 | 35 | | | | | | | | |
| 9.5 | .... | .... | .... | 3 | 6 | 14 | 28 | | | | | | | | |
| 10 | .... | .... | .... | 2 | 5 | 11 | 23 | | | | | | | | |
| 11 | .... | .... | .... | .... | 3 | 7 | 15 | 29 | | | | | | | |
| 12 | .... | .... | .... | .... | 2 | 5 | 11 | 20 | 34 | | | | | | |
| 13 | .... | .... | .... | .... | .... | 4 | 8 | 15 | 25 | | | | | | |
| 14 | .... | .... | .... | .... | .... | 3 | 6 | 11 | 18 | 29 | | | | | |
| 15 | .... | .... | .... | .... | .... | 2 | 4 | 8 | 14 | 22 | 34 | | | | |
| 16 | .... | .... | .... | .... | .... | .... | 3 | 6 | 11 | 17 | 26 | | | | |
| 17 | .... | .... | .... | .... | .... | .... | 3 | 5 | 8 | 13 | 20 | 29 | | | |
| 18 | .... | .... | .... | .... | .... | .... | 2 | 4 | 6 | 10 | 16 | 23 | 33 | | |
| 19 | .... | .... | .... | .... | .... | .... | .... | 3 | 5 | 8 | 13 | 18 | 26 | | |
| 20 | .... | .... | .... | .... | .... | .... | .... | 2 | 4 | 7 | 10 | 15 | 21 | 29 | |
| 21 | .... | .... | .... | .... | .... | .... | .... | 2 | 3 | 6 | 8 | 12 | 18 | 24 | 32 |
| 22 | .... | .... | .... | .... | .... | .... | .... | .... | 3 | 5 | 7 | 10 | 14 | 20 | 27 |
| 23 | .... | .... | .... | .... | .... | .... | .... | .... | 2 | 4 | 6 | 8 | 12 | 16 | 22 |
| 24 | .... | .... | .... | .... | .... | .... | .... | .... | 2 | 3 | 5 | 7 | 10 | 14 | 19 |
| 25 | .... | .... | .... | .... | .... | .... | .... | .... | .... | 3 | 4 | 6 | 9 | 12 | 16 |
| 26 | .... | .... | .... | .... | .... | .... | .... | .... | .... | 2 | 4 | 5 | 7 | 10 | 14 |
| 27 | .... | .... | .... | .... | .... | .... | .... | .... | .... | 2 | 3 | 4 | 6 | 9 | 12 |
| 28 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 3 | 4 | 5 | 7 | 10 |
| 29 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 2 | 3 | 5 | 6 | 9 |
| 30 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 2 | 3 | 4 | 6 | 8 |
| 31 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 3 | 4 | 5 | 7 |
| 32 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | 2 | 3 | 4 | 6 |

# UNDERDRAINS FOR SAND FILTERS.

(No compensating orifices used.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Rate of filtration, million gallons per acre daily. . . . . . . . . . . . . . | 3 | 4 | 5 | 6 | 8 | 10 | 15 |
| Assumed resistance of clean sand, feet . . . . . | 0.090 | 0.120 | 0.150 | 0.180 | 0.240 | 0.300 | 0.450 |
| Total allowable friction and velocity head in underdrainage system | 0.022 | 0.030 | 0.037 | 0.045 | 0.060 | 0.075 | 0.112 |
| Approximate ratio of filter area to area of main drain . . . . . . . . . | 6,300 | 5,600 | 5,100 | 4,700 | 4,200 | 3,800 | 3,200 |
| Approximate velocity in main drain (varying somewhat with size). | 0.67 | 0.80 | 0.90 | 1.00 | 1.18 | 1.34 | 1.68 |
| Approximate velocity in laterals (varying somewhat with size). | 0.40 | 0.48 | 0.55 | 0.61 | 0.72 | 0.82 | 1.04 |

MAXIMUM AREAS DRAINED IN SQUARE FEET.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2″ round lateral. . . . . . | 79 | 70 | 64 | 59 | 53 | 48 | 41 |
| 3″ " " . . . . . . | 180 | 160 | 147 | 137 | 122 | 111 | 93 |
| 4″ " " . . . . . . | 325 | 288 | 264 | 245 | 218 | 200 | 168 |
| 5″ " " . . . . . . | 517 | 460 | 420 | 390 | 345 | 316 | 266 |
| 6″ " " . . . . . . | 750 | 670 | 610 | 570 | 500 | 460 | 390 |
| 8″ " " . . . . . . | 1,340 | 1,200 | 1,090 | 1,010 | 900 | 820 | 690 |
| 6″ split " . . . . . . | 360 | 320 | 290 | 270 | 240 | 220 | 180 |
| 8″ " " . . . . . . | 640 | 570 | 520 | 490 | 430 | 400 | 320 |
| 10″ " " . . . . . . | 1,020 | 900 | 830 | 770 | 680 | 630 | 530 |
| 12″ " " . . . . . . | 1,480 | 1,320 | 1,200 | 1,120 | 1,000 | 910 | 770 |
| 10″ round main. . . . . . . | 3,400 | 3,000 | 2,700 | 2,500 | 2,200 | 2,000 | 1,700 |
| 12″ " " . . . . . . . | 4,900 | 4,300 | 3,900 | 3,600 | 3,200 | 2,900 | 2,400 |
| 15″ " " . . . . . . . | 7,700 | 6,900 | 6,200 | 5,800 | 5,100 | 4,600 | 3,900 |
| 18″ " " . . . . . . . | 11,200 | 10,000 | 9,000 | 8,300 | 7,400 | 6,700 | 5,600 |
| 21″ " " . . . . . . . | 15,300 | 13,600 | 12,300 | 11,400 | 10,000 | 9,100 | 7,600 |
| 24″ " " . . . . . . . | 20,000 | 17,700 | 16,100 | 14,900 | 13,200 | 12,000 | 10,000 |
| 27″ " " . . . . . . . | 25,400 | 22,400 | 20,300 | 18,800 | 16,600 | 15,100 | 12,600 |
| 30″ " " . . . . . . . | 31,500 | 27,800 | 25,300 | 23,400 | 20,700 | 18,800 | 15,700 |
| 33″ " " . . . . . . . | 38,000 | 34,000 | 31,000 | 28,000 | 25,000 | 23,000 | 19,000 |
| 36″ " " . . . . . . . | 45,000 | 40,000 | 37,000 | 34,000 | 30,000 | 27,000 | 22,000 |

*Note.*—For main drains, $c$ is taken as 110, and it is assumed that the space drained is twice as long as wide. For lateral drains, $c$ is taken as 100, and it is assumed that the space drained is four times as long as wide. Considerable change in shape of area drained does not greatly affect the results, and the figures may be used as approximations for all ordinary conditions

# THE FLOW OF WATER OVER WEIRS.

## SHARP-EDGED WEIRS.

THE basis of our experimental knowledge of the discharge of water over weirs of size applicable to the cases usually encountered in practice rests primarily upon three investigations, viz.:

(a) That of Mr. Jas. B. Francis, M. Am. Soc. C. E., made at Lowell, Mass., in 1852.

(b) That of Messrs. Alphonse Fteley and Frederic P. Stearns, Members Am. Soc. C. E., made at Boston, Mass., in 1877, 1878, and 1879.

(c) That of M. Henry Bazin, Inspecteur General des Ponts et Chaussees, made at Dijon, France, in 1886, 1887, and 1888.

Each of these investigations has given rise to a formula for determining the flow of water over a sharp-edged vertical weir without end contractions, named from the observers, and these three formulas comprise those most commonly applied in practice.

The symbols used in these formulas and in the following tables are:

$H$ = the total head or height from the crest of the weir to still water, measured in feet;

$h$ = the observed head or height of the surface of the running water above the crest of the weir, at some convenient point, measured in feet;

$h_v$ = the head to which the mean velocity of the approaching water is due, measured in feet—i.e., $h_v=\frac{v^2}{2g}$—where $v$ = velocity in feet per second;

$L$ = the total length of the crest of the weir, or the mean width of the over-falling sheet at the plane of the weir, measured in feet;

$p$ = the height of the crest of the weir above the bottom of the channel of approach, measured in feet;

$Q$ = the quantity of water discharged per second over a weir, measured in cubic feet;

$g$ = the acceleration due to gravity = 32.16 feet per second.

The Francis formula, then, is:

$$Q = 3.33LH^{3/2} \quad \text{or} \quad Q = 3.33L[(h+h_v)^{3/2} - h_v^{3/2}].$$

The Fteley and Stearns formula is:

$$Q = 3.31LH^{3/2} + 0.007L \quad \text{or} \quad Q = 3.31L(h+1.5h_v)^{3/2} + 0.007L.$$

The Bazin formula is:

$$Q = mLh\sqrt{2gh}, \text{ where } m = \left(0.405 + \frac{0.00984}{h}\right)\left[1 + 0.55\left(\frac{h}{p+h}\right)^2\right].$$

The several observers used different methods of reading the head $h$, and for an accurate application of the formulas the head should be read in the same manner as in the original experiments.

Mr. Francis, in the experiments upon which his formula is based, observed the head as communicated through a small orifice (about $\frac{1}{4}$ inch diameter) in the side of the channel of approach, about 1 foot below the level of the crest and 6 feet up-stream therefrom, which was connected through a pipe about 18 inches long to a cistern, where the surface was read by a hook gage. The weir was of $L = 10$ feet.

In a part of their experiments, which were made on a weir with $L = 5$ feet, Messrs. Fteley and Stearns made use of a small orifice in the center of a plank 10 inches long, set with its face vertical and parallel to the axis of the channel of approach, and about 16 inches from the side wall, so that the orifice was about 10 inches above the bottom and 6 feet up-stream from the weir, the orifice being connected by piping to a movable cistern, in which the head was read by a hook gage. For the rest of their experiments these observers made use of eight small orifices simultaneously, which were connected in pairs, opening in opposite directions. These orifices were in the center of steel plates about 6 inches long, located parallel to the current at about the level of the crest of the weir, and were 6 feet up-stream therefrom, and 18 inches and 7 feet respectively from the side walls of the channel, the weir being of $L = 19$ feet.

In the experiments of M. Bazin, who worked on weirs of $L = 6.56$ feet, 3.28 feet, and 1.64 feet, the head was communicated through an orifice 4 inches in diameter, at the bottom of the channel of approach and 16.3 feet up-stream from the weir, connecting with a pit, wherein the surface of water was located by a hook gage and a dial-float.

Experimental comparisons of these formulas, where the heads were observed in the manner described for each, has shown them to agree

within $2\frac{1}{2}$ per cent for heads from 0.5 up to 3 feet, and that the Fteley and Stearns and the Bazin formulas agree within 2 per cent for heads up to 4 feet. The Francis formula was only intended to apply between heads of 0.5 and 2.0 feet, and should not be used for higher heads. Where other methods of reading the head are used, errors of as much as 10 per cent may be introduced. One of the most erroneous of these is by the aid of a pipe placed in the current parallel to the weir and perforated upon its bottom or top.

A very convenient as well as accurate means of reading the head upon a weir, and one which introduces but a small error, is by the use of a sharp-pointed plumb-bob suspended upon a steel tape, the latter passing over a block on which a line is drawn at right angles to the tape, the reading taken being that of the tape where the line intersects it. The reading of the tape corresponding to the position of the bob when in contact with the water surface, when the latter is at the level of the crest of the weir, must be determined and used as the datum. The point of observation should be far enough away from the crest of the weir to be beyond the curve of the approaching sheet, and the elevation of the water surface may be read by allowing the point of the bob to come in contact with it, the bob being still, or by swinging the bob and allowing it to cut the water surface. Whichever method is adopted should be used in determining the datum reading, as the indications are somewhat different. Such readings will be found to fit the Bazin formula more accurately than they will either of the others.

To facilitate the use of this formula, the following table giving the discharge over weirs of various heights from 2 to 30 feet and for heads from 0.1 to 6.0 feet is presented. The discharges in this table can only be used in cases where the level of the water surface on the down-stream side of the weir is below the crest, and the space between the face of the weir and the over-falling sheet is in free connection with the outside air. If a partial vacuum be formed behind the sheet, from lack of free circulation, the discharge will be increased, under some conditions as much as 5 per cent. If the water on the down-stream side rise above the crest, the weir then becomes submerged or drowned and the discharge is consequently decreased.

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 |
| 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 |
| 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.05 |
| 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 |
| 0.07 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.07 |
| 0.08 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.08 |
| 0.09 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.09 |
| 0.10 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.10 |
| 0.11 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.11 |
| 0.12 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.12 |
| 0.13 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.13 |
| 0.14 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.14 |
| 0.15 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.15 |
| 0.16 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.16 |
| 0.17 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.17 |
| 0.18 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.18 |
| 0.19 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.19 |
| 0.20 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.20 |
| 0.21 | 0.36 | 0.36 | 0.36 | 0.36 | 0.35 | 0.36 | 0.36 | 0.21 |
| 0.22 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.22 |
| 0.23 | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 | 0.23 |
| 0.24 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.24 |
| 0.25 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.25 |
| 0.26 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | 0.26 |
| 0.27 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.27 |
| 0.28 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.28 |
| 0.29 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.29 |
| 0.30 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.30 |
| 0.31 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.31 |
| 0.32 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.32 |
| 0.33 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.33 |
| 0.34 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.34 |
| 0.35 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.35 |
| 0.36 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.36 |
| 0.37 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.37 |
| 0.38 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.38 |
| 0.39 | 0.85 | 0.85 | 0.85 | 0.85 | 0.84 | 0.84 | 0.84 | 0.39 |
| 0.40 | 0.88 | 0.88 | 0.88 | 0.87 | 0.87 | 0.87 | 0.87 | 0.40 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet.
Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. $Q$ Cu. Ft. per Sec. | $p=10$ Ft. $Q$ Cu. Ft. per Sec. | $p=12$ Ft. $Q$ Cu. Ft. per Sec. | $p=16$ Ft. $Q$ Cu. Ft. per Sec. | $p=20$ Ft. $Q$ Cu. Ft. per Sec. | $p=25$ Ft. $Q$ Cu. Ft. per Sec. | $p=30$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 |
| 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 |
| 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.05 |
| 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 |
| 0.07 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.07 |
| 0.08 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.08 |
| 0.09 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.09 |
| 0.10 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.10 |
| 0.11 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.11 |
| 0.12 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.12 |
| 0.13 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.13 |
| 0.14 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.14 |
| 0.15 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.15 |
| 0.16 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.16 |
| 0.17 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.17 |
| 0.18 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.18 |
| 0.19 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.19 |
| 0.20 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.20 |
| 0.21 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.36 | 0.21 |
| 0.22 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.38 | 0.22 |
| 0.23 | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 | 0.41 | 0.23 |
| 0.24 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.24 |
| 0.25 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.25 |
| 0.26 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 | 0.26 |
| 0.27 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.27 |
| 0.28 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.53 | 0.28 |
| 0.29 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.29 |
| 0.30 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.30 |
| 0.31 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.60 | 0.31 |
| 0.32 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 | 0.62 | 0.32 |
| 0.33 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.66 | 0.65 | 0.33 |
| 0.34 | 0.70 | 0.70 | 0.70 | 0.70 | 0.69 | 0.69 | 0.68 | 0.34 |
| 0.35 | 0.73 | 0.73 | 0.73 | 0.72 | 0.72 | 0.72 | 0.71 | 0.35 |
| 0.36 | 0.76 | 0.76 | 0.75 | 0.75 | 0.75 | 0.75 | 0.74 | 0.36 |
| 0.37 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.77 | 0.37 |
| 0.38 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.80 | 0.38 |
| 0.39 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.83 | 0.39 |
| 0.40 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.40 |

DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet | $p=2$ Ft. Q Cu. Ft. per Sec. | $p=3$ Ft. Q Cu. Ft. per Sec. | $p=4$ Ft. Q Cu. Ft. per Sec. | $p=5$ Ft. Q Cu. Ft. per Sec. | $p=6$ Ft. Q Cu. Ft. per Sec. | $p=7$ Ft. Q Cu. Ft. per Sec. | $p=8$ Ft. Q Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 0.41 | 0.92 | 0.92 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.41 |
| 0.42 | 0.95 | 0.95 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.42 |
| 0.43 | 0.99 | 0.99 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.43 |
| 0.44 | 1.02 | 1.02 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 0.44 |
| 0.45 | 1.06 | 1.06 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 0.45 |
| 0.46 | 1.09 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 0.46 |
| 0.47 | 1.13 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.11 | 0.47 |
| 0.48 | 1.16 | 1.15 | 1.15 | 1.15 | 1.15 | 1.14 | 1.14 | 0.48 |
| 0.49 | 1.20 | 1.19 | 1.19 | 1.19 | 1.18 | 1.18 | 1.18 | 0.49 |
| 0.50 | 1.23 | 1.22 | 1.21 | 1.21 | 1.21 | 1.21 | 1.21 | 0.50 |
| 0.51 | 1.27 | 1.26 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 0.51 |
| 0.52 | 1.31 | 1.29 | 1.28 | 1.28 | 1.28 | 1.28 | 1.28 | 0.52 |
| 0.53 | 1.35 | 1.33 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 0.53 |
| 0.54 | 1.38 | 1.36 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 0.54 |
| 0.55 | 1.42 | 1.40 | 1.39 | 1.39 | 1.39 | 1.39 | 1.39 | 0.55 |
| 0.56 | 1.46 | 1.44 | 1.43 | 1.43 | 1.43 | 1.43 | 1.43 | 0.56 |
| 0.57 | 1.50 | 1.48 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 0.57 |
| 0.58 | 1.54 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 | 0.58 |
| 0.59 | 1.58 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 1.55 | 0.59 |
| 0.60 | 1.62 | 1.59 | 1.59 | 1.58 | 1.58 | 1.58 | 1.58 | 0.60 |
| 0.61 | 1.66 | 1.63 | 1.63 | 1.62 | 1.62 | 1.62 | 1.62 | 0.61 |
| 0.62 | 1.70 | 1.67 | 1.67 | 1.66 | 1.66 | 1.66 | 1.66 | 0.62 |
| 0.63 | 1.74 | 1.71 | 1.71 | 1.70 | 1.70 | 1.70 | 1.70 | 0.63 |
| 0.64 | 1.78 | 1.75 | 1.75 | 1.74 | 1.74 | 1.74 | 1.74 | 0.64 |
| 0.65 | 1.82 | 1.79 | 1.79 | 1.78 | 1.78 | 1.78 | 1.78 | 0.65 |
| 0.66 | 1.87 | 1.84 | 1.83 | 1.82 | 1.82 | 1.82 | 1.82 | 0.66 |
| 0.67 | 1.91 | 1.88 | 1.87 | 1.86 | 1.86 | 1.86 | 1.86 | 0.67 |
| 0.68 | 1.95 | 1.92 | 1.91 | 1.90 | 1.90 | 1.90 | 1.90 | 0.68 |
| 0.69 | 2.00 | 1.97 | 1.95 | 1.94 | 1.94 | 1.94 | 1.94 | 0.69 |
| 0.70 | 2.04 | 2.01 | 1.99 | 1.98 | 1.98 | 1.98 | 1.98 | 0.70 |
| 0.71 | 2.09 | 2.06 | 2.03 | 2.02 | 2.02 | 2.02 | 2.02 | 0.71 |
| 0.72 | 2.13 | 2.10 | 2.08 | 2.07 | 2.07 | 2.07 | 2.07 | 0.72 |
| 0.73 | 2.18 | 2.14 | 2.12 | 2.11 | 2.11 | 2.11 | 2.11 | 0.73 |
| 0.74 | 2.22 | 2.18 | 2.16 | 2.15 | 2.15 | 2.15 | 2.15 | 0.74 |
| 0.75 | 2.27 | 2.23 | 2.21 | 2.20 | 2.20 | 2.20 | 2.20 | 0.75 |
| 0.76 | 2.31 | 2.28 | 2.25 | 2.24 | 2.24 | 2.24 | 2.24 | 0.76 |
| 0.77 | 2.36 | 2.32 | 2.30 | 2.29 | 2.29 | 2.28 | 2.28 | 0.77 |
| 0.78 | 2.40 | 2.36 | 2.34 | 2.33 | 2.33 | 2.33 | 2.33 | 0.78 |
| 0.79 | 2.45 | 2.41 | 2.39 | 2.38 | 2.37 | 2.37 | 2.37 | 0.79 |
| 0.80 | 2.50 | 2.45 | 2.43 | 2.42 | 2.41 | 2.41 | 2.41 | 0.80 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet.

Length of weir $=L$.

| $h$ in Feet. | $p$=9 Ft. $Q$ Cu. Ft. per Sec. | $p$=10 Ft. $Q$ Cu. Ft. per Sec. | $p$=12 Ft. $Q$ Cu. Ft. per Sec. | $p$=16 Ft. $Q$ Cu. Ft. per Sec. | $p$=20 Ft. $Q$ Cu. Ft. per Sec. | $p$=25 Ft. $Q$ Cu. Ft per Sec. | $p$=30 Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 0.41 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.90 | 0.90 | 0.41 |
| 0.42 | 0.94 | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 | 0.93 | 0.42 |
| 0.43 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 | 0.97 | 0.43 |
| 0.44 | 1.01 | 1.01 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.44 |
| 0.45 | 1.05 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.03 | 0.45 |
| 0.46 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.06 | 0.46 |
| 0.47 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.10 | 1.10 | 0.47 |
| 0.48 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.13 | 1.13 | 0.48 |
| 0.49 | 1.18 | 1.18 | 1.18 | 1.18 | 1.17 | 1.17 | 1.17 | 0.49 |
| 0.50 | 1.21 | 1.21 | 1.21 | 1.21 | 1.20 | 1.20 | 1.20 | 0.50 |
| 0.51 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 0.51 |
| 0.52 | 1.28 | 1.28 | 1.28 | 1.28 | 1.28 | 1.28 | 1.28 | 0.52 |
| 0.53 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 | 0.53 |
| 0.54 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 0.54 |
| 0.55 | 1.39 | 1.39 | 1.39 | 1.39 | 1.39 | 1.39 | 1.39 | 0.55 |
| 0.56 | 1.43 | 1.43 | 1.43 | 1.43 | 1.43 | 1.43 | 1.43 | 0.56 |
| 0.57 | 1.47 | 1.46 | 1.46 | 1.46 | 1.46 | 1.46 | 1.46 | 0.57 |
| 0.58 | 1.51 | 1.51 | 1.51 | 1.51 | 1.50 | 1.50 | 1.50 | 0.58 |
| 0.59 | 1.55 | 1.54 | 1.54 | 1.54 | 1.54 | 1.54 | 1.53 | 0.59 |
| 0.60 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 0.60 |
| 0.61 | 1.61 | 1.61 | 1.61 | 1.61 | 1.61 | 1.61 | 1.61 | 0.61 |
| 0.62 | 1.65 | 1 65 | 1.65 | 1.65 | 1.65 | 1.65 | 1.65 | 0.62 |
| 0.63 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 0.63 |
| 0.64 | 1.73 | 1.73 | 1.73 | 1.73 | 1.73 | 1.73 | 1.73 | 0.64 |
| 0.65 | 1.77 | 1.77 | 1.77 | 1.77 | 1.77 | 1.77 | 1.77 | 0.65 |
| 0.66 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 1.81 | 0.66 |
| 0.67 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 0.67 |
| 0.68 | 1.89 | 1.89 | 1.89 | 1.89 | 1.89 | 1.89 | 1.89 | 0.68 |
| 0.69 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 0.69 |
| 0.70 | 1.97 | 1.97 | 1.97 | 1.97 | 1.97 | 1.97 | 1.97 | 0.70 |
| 0.71 | 2.01 | 2.01 | 2.01 | 2.01 | 2.01 | 2.01 | 2.01 | 0.71 |
| 0.72 | 2.06 | 2.06 | 2.06 | 2.06 | 2.06 | 2.06 | 2.06 | 0.72 |
| 0.73 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 2.10 | 0.73 |
| 0.74 | 2.14 | 2.14 | 2.14 | 2.14 | 2.14 | 2.14 | 2.14 | 0.74 |
| 0.75 | 2.19 | 2.19 | 2.19 | 2.19 | 2.19 | 2.19 | 2.19 | 0.75 |
| 0.76 | 2.23 | 2.23 | 2.23 | 2.23 | 2.23 | 2.23 | 2.23 | 0.76 |
| 0.77 | 2.27 | 2.27 | 2.27 | 2.27 | 2.27 | 2.27 | 2.27 | 0.77 |
| 0.78 | 2.32 | 2.32 | 2.32 | 2.32 | 2.32 | 2.32 | 2.32 | 0.78 |
| 0.79 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 2.36 | 0.79 |
| 0.80 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 | 0.80 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. Q Cu. Ft. per Sec. | $p=3$ Ft. Q Cu. Ft. per Sec. | $p=4$ Ft. Q Cu. Ft. per Sec. | $p=5$ Ft. Q Cu. Ft. per Sec. | $p=6$ Ft. Q Cu. Ft. per Sec. | $p=7$ Ft. Q Cu. Ft. per Sec. | $p=8$ Ft. Q Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 0.81 | 2.55 | 2.50 | 2.48 | 2.47 | 2.46 | 2.46 | 2.46 | 0.81 |
| 0.82 | 2.60 | 2.55 | 2.52 | 2.51 | 2.50 | 2.50 | 2.50 | 0.82 |
| 0.83 | 2.65 | 2.60 | 2.57 | 2.56 | 2.55 | 2.55 | 2.55 | 0.83 |
| 0.84 | 2.70 | 2.64 | 2.62 | 2.60 | 2.60 | 2.59 | 2.59 | 0.84 |
| 0.85 | 2.75 | 2.69 | 2.66 | 2.65 | 2.64 | 2.64 | 2.64 | 0.85 |
| 0.86 | 2.80 | 2.74 | 2.71 | 2.69 | 2.69 | 2.68 | 2.68 | 0.86 |
| 0.87 | 2.85 | 2.78 | 2.76 | 2.74 | 2.74 | 2.73 | 2.73 | 0.87 |
| 0.88 | 2.90 | 2.83 | 2.80 | 2.78 | 2.78 | 2.77 | 2.77 | 0.88 |
| 0.89 | 2.95 | 2.88 | 2.85 | 2.83 | 2.83 | 2.82 | 2.82 | 0.89 |
| 0.90 | 3.00 | 2.93 | 2.90 | 2.88 | 2.88 | 2.87 | 2.86 | 0.90 |
| 0.91 | 3.05 | 2.98 | 2.94 | 2.93 | 2.92 | 2.92 | 2.91 | 0.91 |
| 0.92 | 3.10 | 3.03 | 2.99 | 2.98 | 2.97 | 2.96 | 2.96 | 0.92 |
| 0.93 | 3.15 | 3.08 | 3.04 | 3.03 | 3.02 | 3.01 | 3.01 | 0.93 |
| 0.94 | 3.21 | 3.13 | 3.09 | 3.08 | 3.07 | 3.06 | 3.05 | 0.94 |
| 0.95 | 3.26 | 3.18 | 3.15 | 3.13 | 3.11 | 3.11 | 3.10 | 0.95 |
| 0.96 | 3.31 | 3.23 | 3.20 | 3.18 | 3.16 | 3.16 | 3.15 | 0.96 |
| 0.97 | 3.37 | 3.28 | 3.25 | 3.23 | 3.21 | 3.21 | 3.20 | 0.97 |
| 0.98 | 3.42 | 3.33 | 3.30 | 3.28 | 3.26 | 3.26 | 3.25 | 0.98 |
| 0.99 | 3.48 | 3.38 | 3.35 | 3.33 | 3.31 | 3.31 | 3.30 | 0.99 |
| 1.00 | 3.53 | 3.44 | 3.40 | 3.38 | 3.36 | 3.36 | 3.35 | 1.00 |
| 1.01 | 3.58 | 3.49 | 3.45 | 3.43 | 3.41 | 3.41 | 3.40 | 1.01 |
| 1.02 | 3.64 | 3.54 | 3.49 | 3.48 | 3.46 | 3.46 | 3.45 | 1.02 |
| 1.03 | 3.69 | 3.60 | 3.55 | 3.54 | 3.51 | 3.51 | 3.50 | 1.03 |
| 1.04 | 3.75 | 3.65 | 3.61 | 3.59 | 3.56 | 3.56 | 3.55 | 1.04 |
| 1.05 | 3.80 | 3.70 | 3.66 | 3.64 | 3.61 | 3.61 | 3.60 | 1.05 |
| 1.06 | 3.86 | 3.76 | 3.71 | 3.69 | 3.66 | 3.66 | 3.65 | 1.06 |
| 1.07 | 3.92 | 3.81 | 3.76 | 3.75 | 3.72 | 3.72 | 3.70 | 1.07 |
| 1.08 | 3.97 | 3.87 | 3.82 | 3.80 | 3.77 | 3.77 | 3.76 | 1.08 |
| 1.09 | 4.03 | 3.92 | 3.87 | 3.85 | 3.82 | 3.82 | 3.81 | 1.09 |
| 1.10 | 4.09 | 3.98 | 3.92 | 3.91 | 3.87 | 3.87 | 3.86 | 1.10 |
| 1.11 | 4.15 | 4.03 | 3.98 | 3.96 | 3.93 | 3.93 | 3.92 | 1.11 |
| 1.12 | 4.20 | 4.09 | 4.03 | 4.02 | 3.98 | 3.98 | 3.97 | 1.12 |
| 1.13 | 4.26 | 4.15 | 4.09 | 4.07 | 4.03 | 4.03 | 4.02 | 1.13 |
| 1.14 | 4.32 | 4.20 | 4.14 | 4.13 | 4.09 | 4.09 | 4.08 | 1.14 |
| 1.15 | 4.38 | 4.26 | 4.20 | 4.18 | 4.14 | 4.14 | 4.13 | 1.15 |
| 1.16 | 4.44 | 4.32 | 4.25 | 4.24 | 4.20 | 4.19 | 4.18 | 1.16 |
| 1.17 | 4.50 | 4.37 | 4.31 | 4.30 | 4.25 | 4.25 | 4.24 | 1.17 |
| 1.18 | 4.56 | 4.43 | 4.37 | 4.35 | 4.31 | 4.30 | 4.29 | 1.18 |
| 1.19 | 4.62 | 4.49 | 4.42 | 4.41 | 4.36 | 4.36 | 4.35 | 1.19 |
| 1.20 | 4.68 | 4.55 | 4.48 | 4.47 | 4.42 | 4.41 | 4.40 | 1.20 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. | $p=10$ Ft. | $p=12$ Ft. | $p=16$ Ft. | $p=20$ Ft. | $p=25$ Ft. | $p=30$ Ft. | $h$ in Feet |
|---|---|---|---|---|---|---|---|---|
| | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | |
| 0.81 | 2.45 | 2.45 | 2.45 | 2.45 | 2.45 | 2.45 | 2.45 | 0.81 |
| 0.82 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 0.82 |
| 0.83 | 2.54 | 2.54 | 2.54 | 2.54 | 2.54 | 2.54 | 2.54 | 0.83 |
| 0.84 | 2.58 | 2.58 | 2.58 | 2.58 | 2.58 | 2.58 | 2.58 | 0.84 |
| 0.85 | 2.63 | 2.63 | 2.63 | 2.63 | 2.63 | 2.63 | 2.63 | 0.85 |
| 0.86 | 2.67 | 2.67 | 2.67 | 2.67 | 2.67 | 2.67 | 2.67 | 0.86 |
| 0.87 | 2.72 | 2.72 | 2.72 | 2.72 | 2.72 | 2.72 | 2.72 | 0.87 |
| 0.88 | 2.76 | 2.76 | 2.76 | 2.76 | 2.76 | 2.76 | 2.76 | 0.88 |
| 0.89 | 2.81 | 2.81 | 2.81 | 2.81 | 2.81 | 2.81 | 2.81 | 0.89 |
| 0.90 | 2.86 | 2.86 | 2.86 | 2.86 | 2.85 | 2.85 | 2.85 | 0.90 |
| 0.91 | 2.91 | 2.90 | 2.90 | 2.90 | 2.90 | 2.90 | 2.90 | 0.91 |
| 0.92 | 2.95 | 2.95 | 2.95 | 2.95 | 2.95 | 2.95 | 2.95 | 0.92 |
| 0.93 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 2.99 | 2.99 | 0.93 |
| 0.94 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.04 | 3.04 | 0.94 |
| 0.95 | 3.10 | 3.09 | 3.09 | 3.09 | 3.09 | 3.09 | 3.09 | 0.95 |
| 0.96 | 3.15 | 3.14 | 3.14 | 3.14 | 3.14 | 3.14 | 3.14 | 0.96 |
| 0.97 | 3.20 | 3.19 | 3.19 | 3.19 | 3.18 | 3.18 | 3.18 | 0.97 |
| 0.98 | 3.25 | 3.24 | 3.24 | 3.24 | 3.23 | 3.23 | 3.23 | 0.98 |
| 0.99 | 3.30 | 3.29 | 3.29 | 3.28 | 3.28 | 3.28 | 3.28 | 0.99 |
| 1.00 | 3.35 | 3.34 | 3.34 | 3.33 | 3.33 | 3.33 | 3.33 | 1.00 |
| 1.01 | 3.40 | 3.39 | 3.39 | 3.39 | 3.38 | 3.38 | 3.38 | 1.01 |
| 1.02 | 3.45 | 3.44 | 3.44 | 3.44 | 3.43 | 3.43 | 3.43 | 1.02 |
| 1.03 | 3.50 | 3.49 | 3.49 | 3.49 | 3.48 | 3.48 | 3.48 | 1.03 |
| 1.04 | 3.55 | 3.54 | 3.54 | 3.54 | 3.53 | 3.53 | 3.53 | 1.04 |
| 1.05 | 3.60 | 3.59 | 3.59 | 3.59 | 3.58 | 3.58 | 3.58 | 1.05 |
| 1.06 | 3.65 | 3.64 | 3.64 | 3.64 | 3.63 | 3.63 | 3.63 | 1.06 |
| 1.07 | 3.70 | 3.69 | 3.69 | 3.69 | 3.68 | 3.68 | 3.68 | 1.07 |
| 1.08 | 3.75 | 3.74 | 3.74 | 3.74 | 3.73 | 3.73 | 3.73 | 1.08 |
| 1.09 | 3.81 | 3.80 | 3.80 | 3.80 | 3.78 | 3.78 | 3.78 | 1.09 |
| 1.10 | 3.86 | 3.85 | 3.85 | 3.85 | 3.84 | 3.84 | 3.84 | 1.10 |
| 1.11 | 3.91 | 3.90 | 3.90 | 3.90 | 3.89 | 3.89 | 3.89 | 1.11 |
| 1.12 | 3.96 | 3.95 | 3.95 | 3.95 | 3.94 | 3.94 | 3.94 | 1.12 |
| 1.13 | 4.02 | 4.01 | 4.01 | 4.01 | 3.99 | 3.99 | 3.99 | 1.13 |
| 1.14 | 4.07 | 4.06 | 4.06 | 4.06 | 4.04 | 4.04 | 4.04 | 1.14 |
| 1.15 | 4.12 | 4.11 | 4.11 | 4.11 | 4.10 | 4.10 | 4.10 | 1.15 |
| 1.16 | 4.18 | 4.17 | 4.17 | 4.17 | 4.15 | 4.15 | 4.15 | 1.16 |
| 1.17 | 4.23 | 4.22 | 4.22 | 4.22 | 4.20 | 4.20 | 4.20 | 1.17 |
| 1.18 | 4.28 | 4.27 | 4.27 | 4.27 | 4.25 | 4.25 | 4.25 | 1.18 |
| 1.19 | 4.34 | 4.33 | 4.33 | 4.32 | 4.31 | 4.31 | 4.31 | 1.19 |
| 1.20 | 4.39 | 4.38 | 4.38 | 4.37 | 4.36 | 4.36 | 4.36 | 1.20 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 1.21 | 4.74 | 4.61 | 4.54 | 4.53 | 4.48 | 4.47 | 4.45 | 1.21 |
| 1.22 | 4.80 | 4.67 | 4.60 | 4.59 | 4.53 | 4.52 | 4.51 | 1.22 |
| 1.23 | 4.86 | 4.73 | 4.66 | 4.64 | 4.59 | 4.58 | 4.56 | 1.23 |
| 1.24 | 4.93 | 4.79 | 4.71 | 4.70 | 4.65 | 4.64 | 4.62 | 1.24 |
| 1.25 | 4.99 | 4.85 | 4.77 | 4.76 | 4.70 | 4.69 | 4.68 | 1.25 |
| 1.26 | 5.05 | 4.91 | 4.83 | 4.82 | 4.76 | 4.75 | 4.73 | 1.26 |
| 1.27 | 5.11 | 4.97 | 4.89 | 4.87 | 4.82 | 4.81 | 4.79 | 1.27 |
| 1.28 | 5.18 | 5.03 | 4.95 | 4.93 | 4.87 | 4.86 | 4.85 | 1.28 |
| 1.29 | 5.24 | 5.09 | 5.01 | 4.99 | 4.93 | 4.92 | 4.91 | 1.29 |
| 1.30 | 5.31 | 5.15 | 5.07 | 5.05 | 4.99 | 4.98 | 4.96 | 1.30 |
| 1.31 | 5.38 | 5.21 | 5.13 | 5.10 | 5.05 | 5.03 | 5.02 | 1.31 |
| 1.32 | 5.44 | 5.28 | 5.19 | 5.16 | 5.10 | 5.09 | 5.08 | 1.32 |
| 1.33 | 5.51 | 5.34 | 5.25 | 5.22 | 5.16 | 5.15 | 5.13 | 1.33 |
| 1.34 | 5.58 | 5.40 | 5.31 | 5.28 | 5.22 | 5.21 | 5.19 | 1.34 |
| 1.35 | 5.65 | 5.46 | 5.37 | 5.33 | 5.28 | 5.26 | 5.25 | 1.35 |
| 1.36 | 5.71 | 5.53 | 5.43 | 5.39 | 5.34 | 5.32 | 5.31 | 1.36 |
| 1.37 | 5.78 | 5.59 | 5.49 | 5.45 | 5.40 | 5.38 | 5.37 | 1.37 |
| 1.38 | 5.85 | 5.65 | 5.55 | 5.51 | 5.46 | 5.44 | 5.42 | 1.38 |
| 1.39 | 5.92 | 5.72 | 5.61 | 5.57 | 5.52 | 5.50 | 5.48 | 1.39 |
| 1.40 | 5.99 | 5.78 | 5.68 | 5.62 | 5.58 | 5.56 | 5.54 | 1.40 |
| 1.41 | 6.05 | 5.84 | 5.74 | 5.68 | 5.64 | 5.62 | 5.60 | 1.41 |
| 1.42 | 6.12 | 5.92 | 5.80 | 5.74 | 5.70 | 5.68 | 5.66 | 1.42 |
| 1.43 | 6.19 | 5.98 | 5.86 | 5.80 | 5.77 | 5.74 | 5.72 | 1.43 |
| 1.44 | 6.26 | 6.04 | 5.92 | 5.86 | 5.83 | 5.80 | 5.78 | 1.44 |
| 1.45 | 6.33 | 6.11 | 5.99 | 5.92 | 5.89 | 5.86 | 5.84 | 1.45 |
| 1.46 | 6.40 | 6.18 | 6.05 | 5.98 | 5.95 | 5.93 | 5.91 | 1.46 |
| 1.47 | 6.47 | 6.24 | 6.11 | 6.05 | 6.01 | 5.99 | 5.97 | 1.47 |
| 1.48 | 6.54 | 6.31 | 6.17 | 6.11 | 6.08 | 6.05 | 6.03 | 1.48 |
| 1.49 | 6.61 | 6.38 | 6.24 | 6.17 | 6.14 | 6.11 | 6.09 | 1.49 |
| 1.50 | 6.68 | 6.44 | 6.30 | 6.23 | 6.20 | 6.18 | 6.16 | 1.50 |
| 1.51 | 6.75 | 6.50 | 6.37 | 6.30 | 6.26 | 6.24 | 6.22 | 1.51 |
| 1.52 | 6.82 | 6.57 | 6.43 | 6.37 | 6.33 | 6.30 | 6.28 | 1.52 |
| 1.53 | 6.89 | 6.65 | 6.50 | 6.44 | 6.39 | 6.36 | 6.33 | 1.53 |
| 1.54 | 6.96 | 6.71 | 6.57 | 6.50 | 6.45 | 6.43 | 6.40 | 1.54 |
| 1.55 | 7.03 | 6.78 | 6.63 | 6.57 | 6.52 | 6.49 | 6.46 | 1.55 |
| 1.56 | 7.10 | 6.85 | 6.70 | 6.64 | 6.58 | 6.54 | 6.53 | 1.56 |
| 1.57 | 7.17 | 6.92 | 6.77 | 6.70 | 6.65 | 6.60 | 6.59 | 1.57 |
| 1.58 | 7.25 | 6.98 | 6.84 | 6.76 | 6.71 | 6.67 | 6.65 | 1.58 |
| 1.59 | 7.32 | 7.05 | 6.90 | 6.83 | 6.78 | 6.73 | 6.72 | 1.59 |
| 1.60 | 7.40 | 7.12 | 6.97 | 6.89 | 6.84 | 6.80 | 6.78 | 1.60 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. | $p=10$ Ft. | $p=12$ Ft. | $p=16$ Ft. | $p=20$ Ft. | $p=25$ Ft. | $p=30$ Ft. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | |
| 1.21 | 4.45 | 4.43 | 4.43 | 4.42 | 4.41 | 4.41 | 4.41 | 1.21 |
| 1.22 | 4.50 | 4.49 | 4.49 | 4.48 | 4.47 | 4.47 | 4.47 | 1.22 |
| 1.23 | 4.55 | 4.54 | 4.54 | 4.53 | 4.52 | 4.52 | 4.52 | 1.23 |
| 1.24 | 4.61 | 4.60 | 4.60 | 4.59 | 4.58 | 4.58 | 4.58 | 1.24 |
| 1.25 | 4.67 | 4.66 | 4.65 | 4.64 | 4.63 | 4.63 | 4.63 | 1.25 |
| 1.26 | 4.72 | 4.71 | 4.71 | 4.70 | 4.69 | 4.69 | 4.69 | 1.26 |
| 1.27 | 4.78 | 4.77 | 4.76 | 4.75 | 4.74 | 4.74 | 4.74 | 1.27 |
| 1.28 | 4.84 | 4.83 | 4.82 | 4.81 | 4.80 | 4.80 | 4.80 | 1.28 |
| 1.29 | 4.90 | 4.89 | 4.87 | 4.86 | 4.85 | 4.85 | 4.85 | 1.29 |
| 1.30 | 4.95 | 4.94 | 4.93 | 4.92 | 4.91 | 4.91 | 4.91 | 1.30 |
| 1.31 | 5.01 | 5.00 | 4.99 | 4.98 | 4.97 | 4.97 | 4.97 | 1.31 |
| 1.32 | 5.07 | 5.06 | 5.04 | 5.03 | 5.02 | 5.02 | 5.02 | 1.32 |
| 1.33 | 5.12 | 5.11 | 5.10 | 5.09 | 5.08 | 5.08 | 5.08 | 1.33 |
| 1.34 | 5.18 | 5.17 | 5.16 | 5.14 | 5.14 | 5.14 | 5.14 | 1.34 |
| 1.35 | 5.24 | 5.23 | 5.22 | 5.20 | 5.20 | 5.19 | 5.19 | 1.35 |
| 1.36 | 5.30 | 5.29 | 5.27 | 5.26 | 5.25 | 5.25 | 5.25 | 1.36 |
| 1.37 | 5.36 | 5.35 | 5.33 | 5.31 | 5.31 | 5.31 | 5.31 | 1.37 |
| 1.38 | 5.41 | 5.40 | 5.39 | 5.37 | 5.37 | 5.36 | 5.36 | 1.38 |
| 1.39 | 5.47 | 5.46 | 5.45 | 5.43 | 5.43 | 5.42 | 5.42 | 1.39 |
| 1.40 | 5.53 | 5.52 | 5.51 | 5.49 | 5.49 | 5.48 | 5.48 | 1.40 |
| 1.41 | 5.59 | 5.58 | 5.57 | 5.55 | 5.55 | 5.53 | 5.54 | 1.41 |
| 1.42 | 5.65 | 5.64 | 5.63 | 5.61 | 5.61 | 5.59 | 5.60 | 1.42 |
| 1.43 | 5.71 | 5.70 | 5.69 | 5.67 | 5.67 | 5.66 | 5.66 | 1.43 |
| 1.44 | 5.77 | 5.76 | 5.75 | 5.73 | 5.73 | 5.71 | 5.72 | 1.44 |
| 1.45 | 5.83 | 5.82 | 5.81 | 5.79 | 5.79 | 5.77 | 5.78 | 1.45 |
| 1.46 | 5.89 | 5.88 | 5.87 | 5.85 | 5.85 | 5.83 | 5.84 | 1.46 |
| 1.47 | 5.95 | 5.94 | 5.93 | 5.91 | 5.91 | 5.89 | 5.90 | 1.47 |
| 1.48 | 6.02 | 6.01 | 5.99 | 5.98 | 5.97 | 5.96 | 5.96 | 1.48 |
| 1.49 | 6.08 | 6.07 | 6.05 | 6.04 | 6.03 | 6.02 | 6.02 | 1.49 |
| 1.50 | 6.14 | 6.13 | 6.12 | 6.11 | 6.10 | 6.09 | 6.09 | 1.50 |
| 1.51 | 6.20 | 6.19 | 6.18 | 6.16 | 6.15 | 6.14 | 6.14 | 1.51 |
| 1.52 | 6.26 | 6.25 | 6.24 | 6.22 | 6.21 | 6.21 | 6.20 | 1.52 |
| 1.53 | 6.32 | 6.31 | 6.30 | 6.28 | 6.27 | 6.26 | 6.26 | 1.53 |
| 1.54 | 5.38 | 6.37 | 6.36 | 6.34 | 6.33 | 6.32 | 6.32 | 1.54 |
| 1.55 | 6.45 | 6.43 | 6.42 | 6.40 | 6.39 | 6.38 | 6.38 | 1.55 |
| 1.56 | 6.51 | 6.50 | 6.49 | 6.47 | 6.45 | 6.45 | 6.45 | 1.56 |
| 1.57 | 6.57 | 6.56 | 6.55 | 6.53 | 6.51 | 6.51 | 6.51 | 1.57 |
| 1.58 | 6.63 | 6.62 | 6.61 | 6.59 | 6.57 | 6.57 | 6.57 | 1.58 |
| 1.59 | 6.70 | 6.68 | 6.67 | 6.65 | 6.63 | 6.63 | 6.63 | 1.59 |
| 1.60 | 6.76 | 6.74 | 6.73 | 6.71 | 6.69 | 6.69 | 6.69 | 1.60 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p$=2 Ft. | $p$=3 Ft. | $p$=4 Ft. | $p$=5 Ft. | $p$=6 Ft. | $p$=7 Ft. | $p$=8 Ft. | $h$ in Feet |
|---|---|---|---|---|---|---|---|---|
| | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | |
| 1.61 | 7.47 | 7.19 | 7.04 | 6.96 | 6.90 | 6.86 | 6.84 | 1.61 |
| 1.62 | 7.54 | 7.26 | 7.11 | 7.03 | 6.97 | 6.92 | 6.91 | 1.62 |
| 1.63 | 7.62 | 7.33 | 7.17 | 7.09 | 7.03 | 6.99 | 6.97 | 1.63 |
| 1.64 | 7.69 | 7.40 | 7.24 | 7.16 | 7.10 | 7.05 | 7.03 | 1.64 |
| 1.65 | 7.76 | 7.47 | 7.31 | 7.23 | 7.16 | 7.11 | 7.10 | 1.65 |
| 1.66 | 7.83 | 7.54 | 7.38 | 7.29 | 7.23 | 7.18 | 7.16 | 1.66 |
| 1.67 | 7.91 | 7.61 | 7.45 | 7.36 | 7.29 | 7.24 | 7.23 | 1.67 |
| 1.68 | 7.98 | 7.69 | 7.52 | 7.43 | 7.36 | 7.31 | 7.29 | 1.68 |
| 1.69 | 8.06 | 7.76 | 7.59 | 7.49 | 7.43 | 7.38 | 7.36 | 1.69 |
| 1.70 | 8.14 | 7.83 | 7.66 | 7.56 | 7.49 | 7.44 | 7.42 | 1.70 |
| 1.71 | 8.22 | 7.90 | 7.73 | 7.63 | 7.56 | 7.51 | 7.49 | 1.71 |
| 1.72 | 8.29 | 7.97 | 7.80 | 7.70 | 7.63 | 7.58 | 7.55 | 1.72 |
| 1.73 | 8.37 | 8.05 | 7.87 | 7.76 | 7.70 | 7.65 | 7.62 | 1.73 |
| 1.74 | 8.45 | 8.12 | 7.94 | 7.83 | 7.76 | 7.71 | 7.69 | 1.74 |
| 1.75 | 8.53 | 8.19 | 8.01 | 7.90 | 7.83 | 7.78 | 7.75 | 1.75 |
| 1.76 | 8.61 | 8.26 | 8.09 | 7.97 | 7.90 | 7.85 | 7.82 | 1.76 |
| 1.77 | 8.69 | 8.34 | 8.16 | 8.04 | 7.97 | 7.92 | 7.89 | 1.77 |
| 1.78 | 8.77 | 8.41 | 8.23 | 8.11 | 8.04 | 7.99 | 7.96 | 1.78 |
| 1.79 | 8.85 | 8.48 | 8.30 | 8.18 | 8.11 | 8.06 | 8.02 | 1.79 |
| 1.80 | 8.93 | 8.56 | 8.37 | 8.25 | 8.18 | 8.13 | 8.09 | 1.80 |
| 1.81 | 9.01 | 8.63 | 8.45 | 8.32 | 8.25 | 8.20 | 8.16 | 1.81 |
| 1.82 | 9.09 | 8.71 | 8.52 | 8.39 | 8.32 | 8.27 | 8.23 | 1.82 |
| 1.83 | 9.17 | 8.78 | 8.59 | 8.46 | 8.39 | 8.34 | 8.30 | 1.83 |
| 1.84 | 9.25 | 8.86 | 8.66 | 8.53 | 8.46 | 8.41 | 8.37 | 1.84 |
| 1.85 | 9.34 | 8.94 | 8.74 | 8.61 | 8.53 | 8.48 | 8.44 | 1.85 |
| 1.86 | 9.42 | 9.01 | 8.81 | 8.68 | 8.61 | 8.55 | 8.51 | 1.86 |
| 1.87 | 9.50 | 9.09 | 8.88 | 8.75 | 8.68 | 8.62 | 8.58 | 1.87 |
| 1.88 | 9.58 | 9.17 | 8.96 | 8.82 | 8.75 | 8.69 | 8.65 | 1.88 |
| 1.89 | 9.66 | 9.25 | 9.03 | 8.90 | 8.82 | 8.76 | 8.72 | 1.89 |
| 1.90 | 9.75 | 9.32 | 9.11 | 8.97 | 8.89 | 8.83 | 8.79 | 1.90 |
| 1.91 | 9.83 | 9.40 | 9.18 | 9.04 | 8.97 | 8.91 | 8.87 | 1.91 |
| 1.92 | 9.91 | 9.48 | 9.26 | 9.12 | 9.04 | 8.98 | 8.94 | 1.92 |
| 1.93 | 9.99 | 9.56 | 9.33 | 9.19 | 9.11 | 9.05 | 9.01 | 1.93 |
| 1.94 | 10.08 | 9.64 | 9.41 | 9.27 | 9.18 | 9.12 | 9.08 | 1.94 |
| 1.95 | 10.16 | 9.72 | 9.48 | 9.34 | 9.26 | 9.19 | 9.15 | 1.95 |
| 1.96 | 10.24 | 9.80 | 9.56 | 9.42 | 9.33 | 9.26 | 9.22 | 1.96 |
| 1.97 | 10.33 | 9.88 | 9.64 | 9.49 | 9.40 | 9.34 | 9.30 | 1.97 |
| 1.98 | 10.41 | 9.96 | 9.71 | 9.57 | 9.48 | 9.41 | 9.37 | 1.98 |
| 1.99 | 10.50 | 10.04 | 9.79 | 9.64 | 9.55 | 9.48 | 9.44 | 1.99 |
| 2.00 | 10.58 | 10.12 | 9.87 | 9.72 | 9.62 | 9.55 | 9.51 | 2.00 |

DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet.
Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. | $p=10$ Ft. | $p=12$ Ft. | $p=16$ Ft. | $p=20$ Ft. | $p=25$ Ft. | $p=30$ Ft. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | |
| 1.61 | 6.82 | 6.81 | 6.79 | 6.78 | 6.76 | 6.76 | 6.76 | 1.61 |
| 1.62 | 6.89 | 6.87 | 6.86 | 6.84 | 6.82 | 6.82 | 6.82 | 1.62 |
| 1.63 | 6.95 | 6.93 | 6.92 | 6.90 | 6.88 | 6.88 | 6.88 | 1.63 |
| 1.64 | 7.01 | 6.99 | 6.98 | 6.96 | 6.94 | 6.94 | 6.94 | 1.64 |
| 1.65 | 7.08 | 7.06 | 7.05 | 7.03 | 7.01 | 7.00 | 7.00 | 1.65 |
| 1.66 | 7.14 | 7.13 | 7.11 | 7.09 | 7.07 | 7.07 | 7.07 | 1.66 |
| 1.67 | 7.21 | 7.20 | 7.17 | 7.15 | 7.13 | 7.13 | 7.13 | 1.67 |
| 1.68 | 7.27 | 7.26 | 7.24 | 7.22 | 7.20 | 7.19 | 7.19 | 1.68 |
| 1.69 | 7.34 | 7.33 | 7.30 | 7.28 | 7.26 | 7.26 | 7.26 | 1.69 |
| 1.70 | 7.40 | 7.39 | 7.37 | 7.34 | 7.33 | 7.32 | 7.32 | 1.70 |
| 1.71 | 7.47 | 7.46 | 7.43 | 7.41 | 7.39 | 7.39 | 7.38 | 1.71 |
| 1.72 | 7.53 | 7.52 | 7.50 | 7.47 | 7.46 | 7.45 | 7.45 | 1.72 |
| 1.73 | 7.60 | 7.59 | 7.56 | 7.54 | 7.52 | 7.52 | 7.51 | 1.73 |
| 1.74 | 7.67 | 7.66 | 7.63 | 7.60 | 7.59 | 7.58 | 7.57 | 1.74 |
| 1.75 | 7.73 | 7.72 | 7.69 | 7.67 | 7.65 | 7.65 | 7.63 | 1.75 |
| 1.76 | 7.80 | 7.79 | 7.76 | 7.73 | 7.72 | 7.71 | 7.70 | 1.76 |
| 1.77 | 7.87 | 7.86 | 7.82 | 7.80 | 7.78 | 7.78 | 7.77 | 1.77 |
| 1.78 | 7.94 | 7.93 | 7.89 | 7.86 | 7.85 | 7.84 | 7.83 | 1.78 |
| 1.79 | 8.00 | 7.99 | 7.96 | 7.93 | 7.92 | 7.91 | 7.90 | 1.79 |
| 1.80 | 8.07 | 8.05 | 8.02 | 7.99 | 7.98 | 7.97 | 7.96 | 1.80 |
| 1.81 | 8.14 | 8.12 | 8.09 | 8.06 | 8.05 | 8.04 | 8.03 | 1.81 |
| 1.82 | 8.21 | 8.19 | 8.16 | 8.13 | 8.11 | 8.10 | 8.10 | 1.82 |
| 1.83 | 8.28 | 8.26 | 8.23 | 8.19 | 8.18 | 8.17 | 8.16 | 1.83 |
| 1.84 | 8.35 | 8.32 | 8.29 | 8.26 | 8.24 | 8.23 | 8.23 | 1.84 |
| 1.85 | 8.42 | 8.39 | 8.36 | 8.33 | 8.31 | 8.30 | 8.30 | 1.85 |
| 1.86 | 8.49 | 8.46 | 8.43 | 8.40 | 8.38 | 3.37 | 8.36 | 1.86 |
| 1.87 | 8.56 | 8.53 | 8.50 | 8.46 | 8.44 | 8.43 | 8.43 | 1.87 |
| 1.88 | 8.63 | 8.60 | 8.57 | 8.53 | 8.51 | 8.50 | 8.50 | 1.88 |
| 1.89 | 8.70 | 8.67 | 8.63 | 8.60 | 8.58 | 8.57 | 8.57 | 1.89 |
| 1.90 | 8.77 | 8.74 | 8.70 | 8.67 | 8.65 | 8.64 | 8.63 | 1.90 |
| 1.91 | 8.84 | 8.81 | 8.77 | 8.74 | 8.71 | 8.70 | 8.70 | 1.91 |
| 1.92 | 8.91 | 8.88 | 8.84 | 8 80 | 8.78 | 8.77 | 8.77 | 1.92 |
| 1.93 | 8.98 | 8.95 | 8.91 | 8.87 | 8.85 | 8.84 | 8.84 | 1.93 |
| 1.94 | 9.05 | 9.02 | 8.98 | 8.94 | 8.92 | 8.91 | 8.90 | 1.94 |
| 1.95 | 9.12 | 9.09 | 9.05 | 9.01 | 8.99 | 8 98 | 8.97 | 1.95 |
| 1.96 | 9.19 | 9.16 | 9.12 | 9.08 | 9.06 | 9.05 | 9.04 | 1.96 |
| 1.97 | 9.26 | 9.23 | 9.19 | 9.15 | 9.13 | 9.12 | 9.11 | 1.97 |
| 1.98 | 9.33 | 9.30 | 9.26 | 9.22 | 9.20 | 9.19 | 9.18 | 1.98 |
| 1.99 | 9.40 | 9.37 | 9.33 | 9.29 | 9.26 | 9.26 | 9.25 | 1.99 |
| 2.00 | 9.47 | 9.44 | 9.40 | 9.36 | 9.34 | 9.33 | 9.32 | 2.00 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet |
|---|---|---|---|---|---|---|---|---|
| 2.01 | 10.67 | 10.20 | 9.95 | 9.79 | 9.70 | 9.63 | 9.59 | 2.01 |
| 2.02 | 10.75 | 10.28 | 10.02 | 9.87 | 9.77 | 9.70 | 9.66 | 2.02 |
| 2.03 | 10.84 | 10.36 | 10.10 | 9.94 | 9.85 | 9.78 | 9.73 | 2.03 |
| 2.04 | 10.93 | 10.44 | 10.18 | 10.02 | 9.92 | 9.85 | 9.81 | 2.04 |
| 2.05 | 11.01 | 10.52 | 10.26 | 10.09 | 10.00 | 9.93 | 9.88 | 2.05 |
| 2.06 | 11.10 | 10.60 | 10.34 | 10.17 | 10.07 | 10.01 | 9.95 | 2.06 |
| 2.07 | 11.19 | 10.68 | 10.41 | 10.25 | 10.15 | 10.09 | 10.03 | 2.07 |
| 2.08 | 11.27 | 10.76 | 10.49 | 10.32 | 10.22 | 10.16 | 10.10 | 2.08 |
| 2.09 | 11.36 | 10.85 | 10.57 | 10.40 | 10.30 | 10.24 | 10.17 | 2.09 |
| 2.10 | 11.45 | 10.93 | 10.65 | 10.48 | 10.37 | 10.31 | 10.25 | 2.10 |
| 2.11 | 11.53 | 11.01 | 10.73 | 10.56 | 10.45 | 10.39 | 10.32 | 2.11 |
| 2.12 | 11.62 | 11.10 | 10.81 | 10.63 | 10.53 | 10.46 | 10.39 | 2.12 |
| 2.13 | 11.71 | 11.18 | 10.89 | 10.71 | 10.60 | 10.54 | 10.47 | 2.13 |
| 2.14 | 11.80 | 11.26 | 10.97 | 10.79 | 10.68 | 10.61 | 10.54 | 2.14 |
| 2.15 | 11.88 | 11.35 | 11.05 | 10.87 | 10.76 | 10.69 | 10.62 | 2.15 |
| 2.16 | 11.97 | 11.43 | 11.13 | 10.95 | 10.83 | 10.76 | 10.69 | 2.16 |
| 2.17 | 12.06 | 11.51 | 11.21 | 11.03 | 10.91 | 10.84 | 10.77 | 2.17 |
| 2.18 | 12.15 | 11.60 | 11.29 | 11.11 | 10.99 | 10.91 | 10.84 | 2.18 |
| 2.19 | 12.24 | 11.68 | 11.39 | 11.19 | 11.07 | 10.98 | 10.92 | 2.19 |
| 2.20 | 12.34 | 11.77 | 11.46 | 11.27 | 11.14 | 11.06 | 10.99 | 2.20 |
| 2.21 | 12.43 | 11.85 | 11.54 | 11.35 | 11.22 | 11.13 | 11.07 | 2.21 |
| 2.22 | 12.52 | 11.94 | 11.62 | 11.43 | 11.30 | 11.21 | 11.15 | 2.22 |
| 2.23 | 12.61 | 12.02 | 11.70 | 11.51 | 11.38 | 11.29 | 11.22 | 2.23 |
| 2.24 | 12.70 | 12.11 | 11.79 | 11.59 | 11.45 | 11.36 | 11.30 | 2.24 |
| 2.25 | 12.79 | 12.20 | 11.87 | 11.67 | 11.53 | 11.44 | 11.38 | 2.25 |
| 2.26 | 12.88 | 12.29 | 11.95 | 11.75 | 11.61 | 11.52 | 11.46 | 2.26 |
| 2.27 | 12.98 | 12.37 | 12.04 | 11.83 | 11.69 | 11.60 | 11.53 | 2.27 |
| 2.28 | 13.06 | 12.46 | 12.12 | 11.91 | 11.77 | 11.67 | 11.61 | 2.28 |
| 2.29 | 13.15 | 12.55 | 12.20 | 11.99 | 11.85 | 11.75 | 11.69 | 2.29 |
| 2.30 | 13.24 | 12.64 | 12.29 | 12.07 | 11.93 | 11.83 | 11.77 | 2.30 |
| 2.31 | 13.33 | 12.73 | 12.37 | 12.16 | 12.01 | 11.90 | 11.84 | 2.31 |
| 2.32 | 13.44 | 12.81 | 12.46 | 12.24 | 12.09 | 11.99 | 11.92 | 2.32 |
| 2.33 | 13.53 | 12.90 | 12.54 | 12.32 | 12.17 | 12.07 | 12.00 | 2.33 |
| 2.34 | 13.63 | 12.99 | 12.63 | 12.40 | 12.26 | 12.15 | 12.08 | 2.34 |
| 2.35 | 13.72 | 13.08 | 12.71 | 12.49 | 12.34 | 12.23 | 12.16 | 2.35 |
| 2.36 | 13.82 | 13.17 | 12.80 | 12.57 | 12.42 | 12.31 | 12.24 | 2.36 |
| 2.37 | 13.91 | 13.26 | 12.89 | 12.65 | 12.50 | 12.39 | 12.32 | 2.37 |
| 2.38 | 14.01 | 13.35 | 12.97 | 12.74 | 12.58 | 12.47 | 12.40 | 2.38 |
| 2.39 | 14.10 | 13.44 | 13.06 | 12.82 | 12.67 | 12.55 | 12.48 | 2.39 |
| 2.40 | 14.20 | 13.53 | 13.15 | 12.91 | 12.75 | 12.64 | 12.56 | 2.40 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. $Q$ Cu. Ft. per Sec. | $p=10$ Ft. $Q$ Cu. Ft. per Sec. | $p=12$ Ft. $Q$ Cu. Ft. per Sec. | $p=16$ Ft. $Q$ Cu. Ft. per Sec. | $p=20$ Ft. $Q$ Cu. Ft. per Sec. | $p=25$ Ft. $Q$ Cu. Ft per Sec. | $p=30$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 2.01 | 9.55 | 9.52 | 9.48 | 9.44 | 9.41 | 9.40 | 9.39 | 2.01 |
| 2.02 | 9.62 | 9.59 | 9.55 | 9.51 | 9.48 | 9.47 | 9.46 | 2.02 |
| 2.03 | 9.69 | 9.66 | 9.62 | 9.58 | 9.55 | 9.54 | 9.53 | 2.03 |
| 2.04 | 9.77 | 9.73 | 9.69 | 9.65 | 9.62 | 9.61 | 9.60 | 2.04 |
| 2.05 | 9.84 | 9.81 | 9.76 | 9.72 | 9.69 | 9.68 | 9.67 | 2.05 |
| 2.06 | 9.91 | 9.88 | 9.84 | 9.79 | 9.76 | 9.75 | 9.74 | 2.06 |
| 2.07 | 9.99 | 9.95 | 9.91 | 9.87 | 9.84 | 9.82 | 9.81 | 2.07 |
| 2.08 | 10.06 | 10.03 | 9.98 | 9.94 | 9.91 | 9.89 | 9.88 | 2.08 |
| 2.09 | 10.13 | 10.10 | 10.05 | 10.01 | 9.98 | 9.96 | 9.95 | 2.09 |
| 2.10 | 10.21 | 10.17 | 10.13 | 10.08 | 10.05 | 10.03 | 10.02 | 2.10 |
| 2.11 | 10.28 | 10.25 | 10.20 | 10.15 | 10.12 | 10.10 | 10.09 | 2.11 |
| 2.12 | 10.36 | 10.32 | 10.27 | 10.23 | 10.20 | 10.17 | 10.16 | 2.12 |
| 2.13 | 10.43 | 10.39 | 10.35 | 10.30 | 10.27 | 10.25 | 10.24 | 2.13 |
| 2.14 | 10.50 | 10.47 | 10.42 | 10.37 | 10.34 | 10.32 | 10.31 | 2.14 |
| 2.15 | 10.58 | 10.54 | 10.49 | 10.44 | 10.41 | 10.39 | 10.38 | 2.15 |
| 2.16 | 10.65 | 10.61 | 10.57 | 10.51 | 10.48 | 10.46 | 10.45 | 2.16 |
| 2.17 | 10.73 | 10.69 | 10.64 | 10.59 | 10.56 | 10.54 | 10.53 | 2.17 |
| 2.18 | 10.80 | 10.76 | 10.71 | 10.66 | 10.63 | 10.61 | 10.60 | 2.18 |
| 2.19 | 10.88 | 10.83 | 10.79 | 10.73 | 10.70 | 10.68 | 10.67 | 2.19 |
| 2.20 | 10.95 | 10.91 | 10.86 | 10.81 | 10.78 | 10.76 | 10.75 | 2.20 |
| 2.21 | 11.03 | 10.98 | 10.94 | 10.88 | 10.85 | 10.83 | 10.82 | 2.21 |
| 2.22 | 11.10 | 11.06 | 11.01 | 10.95 | 10.92 | 10.90 | 10.89 | 2.22 |
| 2.23 | 11.18 | 11.13 | 11.09 | 11.03 | 11.00 | 10.98 | 10.97 | 2.23 |
| 2.24 | 11.25 | 11.21 | 11.16 | 11.10 | 11.07 | 11.05 | 11.04 | 2.24 |
| 2.25 | 11.33 | 11.28 | 11.24 | 11.17 | 11.14 | 11.12 | 11.11 | 2.25 |
| 2.26 | 11.41 | 11.36 | 11.31 | 11.25 | 11.22 | 11.20 | 11.19 | 2.26 |
| 2.27 | 11.48 | 11.43 | 11.39 | 11.32 | 11.29 | 11.27 | 11.26 | 2.27 |
| 2.28 | 11.56 | 11.51 | 11.46 | 11.39 | 11.37 | 11.34 | 11.33 | 2.28 |
| 2.29 | 11.64 | 11.59 | 11.54 | 11.47 | 11.44 | 11.42 | 11.41 | 2.29 |
| 2.30 | 11.71 | 11.66 | 11.61 | 11.55 | 11.52 | 11.49 | 11.48 | 2.30 |
| 2.31 | 11.79 | 11.74 | 11.69 | 11.63 | 11.59 | 11.57 | 11.56 | 2.31 |
| 2.32 | 11.87 | 11.82 | 11.77 | 11.70 | 11.67 | 11.64 | 11.63 | 2.32 |
| 2.33 | 11.95 | 11.90 | 11.84 | 11.78 | 11.74 | 11.72 | 11.71 | 2.33 |
| 2.34 | 12.02 | 11.98 | 11.92 | 11.85 | 11.82 | 11.79 | 11.78 | 2.34 |
| 2.35 | 12.10 | 12.06 | 12.00 | 11.93 | 11.90 | 11.87 | 11.86 | 2.35 |
| 2.36 | 12.18 | 12.13 | 12.08 | 12.01 | 11.97 | 11.95 | 11.94 | 2.36 |
| 2.37 | 12.26 | 12.21 | 12.15 | 12.08 | 12.05 | 12.02 | 12.01 | 2.37 |
| 2.38 | 12.34 | 12.29 | 12.23 | 12.16 | 12.13 | 12.10 | 12.09 | 2.38 |
| 2.39 | 12.42 | 12.37 | 12.31 | 12.24 | 12.20 | 12.18 | 12.17 | 2.39 |
| 2.40 | 12.50 | 12.45 | 12.39 | 12.32 | 12.28 | 12.25 | 12.24 | 2.40 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 2.41 | 14.30 | 13.62 | 13.23 | 12.99 | 12.83 | 12.72 | 12.64 | 2.41 |
| 2.42 | 14.40 | 13.72 | 13.32 | 13.08 | 12.91 | 12.80 | 12.72 | 2.42 |
| 2.43 | 14.49 | 13.81 | 13.40 | 13.16 | 13.00 | 12.88 | 12.80 | 2.43 |
| 2.44 | 14.59 | 13.90 | 13.49 | 13.25 | 13.08 | 12.97 | 12.88 | 2.44 |
| 2.45 | 14.69 | 13.99 | 13.58 | 13.33 | 13.16 | 13.05 | 12.96 | 2.45 |
| 2.46 | 14.78 | 14.08 | 13.66 | 13.42 | 13.25 | 13.13 | 13.05 | 2.46 |
| 2.47 | 14.88 | 14.18 | 13.75 | 13.50 | 13.34 | 13.22 | 13.13 | 2.47 |
| 2.48 | 14.98 | 14.27 | 13.84 | 13.59 | 13.42 | 13.30 | 13.21 | 2.48 |
| 2.49 | 15.08 | 14.36 | 13.92 | 13.67 | 13.51 | 13.38 | 13.29 | 2.49 |
| 2.50 | 15.17 | 14.45 | 14.03 | 13.76 | 13.59 | 13.47 | 13.38 | 2.50 |
| 2.51 | 15.27 | 14.55 | 14.11 | 13.85 | 13.68 | 13.55 | 13.46 | 2.51 |
| 2.52 | 15.37 | 14.64 | 14.20 | 13.93 | 13.76 | 13.63 | 13.54 | 2.52 |
| 2.53 | 15.47 | 14.73 | 14.29 | 14.02 | 13.85 | 13.70 | 13.62 | 2.53 |
| 2.54 | 15.57 | 14.82 | 14.38 | 14.11 | 13.93 | 13.80 | 13.71 | 2.54 |
| 2.55 | 15.67 | 14.92 | 14.47 | 14.20 | 14.02 | 13.88 | 13.79 | 2.55 |
| 2.56 | 15.77 | 15.01 | 14.56 | 14.28 | 14.10 | 13.96 | 13.87 | 2.56 |
| 2.57 | 15.86 | 15.10 | 14.65 | 14.37 | 14.19 | 14.05 | 13.95 | 2.57 |
| 2.58 | 15.96 | 15.19 | 14.74 | 14.46 | 14.27 | 14.13 | 14.03 | 2.58 |
| 2.59 | 16.06 | 15.29 | 14.83 | 14.54 | 14.36 | 14.21 | 14.11 | 2.59 |
| 2.60 | 16.16 | 15.38 | 14.92 | 14.63 | 14.44 | 14.30 | 14.20 | 2.60 |
| 2.61 | 16.26 | 15.47 | 15.01 | 14.72 | 14.53 | 14.38 | 14.28 | 2.61 |
| 2.62 | 16.36 | 15.57 | 15.10 | 14.81 | 14.62 | 14.46 | 14.36 | 2.62 |
| 2.63 | 16.46 | 15.66 | 15.19 | 14.90 | 14.70 | 14.55 | 14.45 | 2.63 |
| 2.64 | 16.57 | 15.76 | 15.28 | 14.99 | 14.79 | 14.63 | 14.53 | 2.64 |
| 2.65 | 16.67 | 15.85 | 15.37 | 15.08 | 14.88 | 14.72 | 14.62 | 2.65 |
| 2.66 | 16.77 | 15.95 | 15.46 | 15.16 | 14.96 | 14.80 | 14.70 | 2.66 |
| 2.67 | 16.87 | 16.05 | 15.55 | 15.25 | 15.05 | 14.89 | 14.79 | 2.67 |
| 2.68 | 16.98 | 16.10 | 15.64 | 15.34 | 15.14 | 14.97 | 14.87 | 2.68 |
| 2.69 | 17.08 | 16.24 | 15.74 | 15.43 | 15.23 | 15.06 | 14.96 | 2.69 |
| 2.70 | 17.18 | 16.34 | 15.83 | 15.52 | 15.31 | 15.15 | 15.04 | 2.70 |
| 2.71 | 17.28 | 16.43 | 15.92 | 15.61 | 15.40 | 15.23 | 15.13 | 2.71 |
| 2.72 | 17.39 | 16.53 | 16.02 | 15.70 | 15.49 | 15.32 | 15.22 | 2.72 |
| 2.73 | 17.49 | 16.63 | 16.11 | 15.79 | 15.58 | 15.41 | 15.30 | 2.73 |
| 2.74 | 17.60 | 16.73 | 16.24 | 15.88 | 15.67 | 15.50 | 15.39 | 2.74 |
| 2.75 | 17.70 | 16.82 | 16.30 | 15.98 | 15.76 | 15.59 | 15.48 | 2.75 |
| 2.76 | 17.81 | 16.92 | 16.40 | 16.07 | 15.85 | 15.68 | 15.56 | 2.76 |
| 2.77 | 17.91 | 17.02 | 16.50 | 16.16 | 15.94 | 15.77 | 15.65 | 2.77 |
| 2.78 | 18.02 | 17.12 | 16.59 | 16.25 | 16.03 | 15.86 | 15.74 | 2.78 |
| 2.79 | 18.12 | 17.22 | 16.69 | 16.34 | 16.12 | 15.95 | 15.83 | 2.79 |
| 2.80 | 18.23 | 17.32 | 16.79 | 16.44 | 16.21 | 16.04 | 15.92 | 2.80 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q = \left(0.405 + \frac{.00984}{h}\right)\left[1 + 9.55\frac{h^2}{(p+h)^2}\right] Lh\sqrt{2gh}.$$

Observed head $= h$. Height of weir $= p$. Discharge $= Q$. $g = 32.17$ feet. Length of weir $= L$.

| $h$ in Feet. | $p=9$ Ft. $Q$ Cu. Ft. Per Sec. | $p=10$ Ft. $Q$ Cu. Ft. Per Sec. | $p=12$ Ft. $Q$ Cu. Ft. Per Sec. | $p=16$ Ft. $Q$ Cu. Ft. Per Sec. | $p=20$ Ft. $Q$ Cu. Ft. Per Sec. | $p=25$ Ft. $Q$ Cu. Ft. Per Sec. | $p=30$ Ft. $Q$ Cu. Ft. Per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 2.41 | 12.58 | 12.53 | 12.47 | 12.40 | 12.36 | 12.33 | 12.32 | 2.41 |
| 2.42 | 12.66 | 12.63 | 12.55 | 12.48 | 12.44 | 12.41 | 12.39 | 2.42 |
| 2.43 | 12.74 | 12.70 | 12.63 | 12.56 | 12.52 | 12.48 | 12.47 | 2.43 |
| 2.44 | 12.82 | 12.78 | 12.70 | 12.63 | 12.60 | 12.56 | 12.55 | 2.44 |
| 2.45 | 12.90 | 12.86 | 12.78 | 12.72 | 12.67 | 12.63 | 12.63 | 2.45 |
| 2.46 | 12.98 | 12.94 | 12.86 | 12.79 | 12.75 | 12.71 | 12.71 | 2.46 |
| 2.47 | 13.07 | 13.02 | 12.94 | 12.87 | 12.83 | 12.79 | 12.78 | 2.47 |
| 2.48 | 13.15 | 13.10 | 13.02 | 12.95 | 12.90 | 12.87 | 12.86 | 2.48 |
| 2.49 | 13.23 | 13.18 | 13.10 | 13.02 | 12.98 | 12.95 | 12.94 | 2.49 |
| 2.50 | 13.31 | 13.26 | 13.18 | 13.10 | 13.06 | 13.03 | 13.01 | 2.50 |
| 2.51 | 13.39 | 13.34 | 13.27 | 13.18 | 13.14 | 13.11 | 13.09 | 2.51 |
| 2.52 | 13.47 | 13.42 | 13.35 | 13.26 | 13.22 | 13.19 | 13.17 | 2.52 |
| 2.53 | 13.56 | 13.50 | 13.43 | 13.34 | 13.30 | 13.26 | 13.25 | 2.53 |
| 2.54 | 13.64 | 13.58 | 13.51 | 13.41 | 13.38 | 13.34 | 13.33 | 2.54 |
| 2.55 | 13.72 | 13.66 | 13.59 | 13.49 | 13.45 | 13.42 | 13.41 | 2.55 |
| 2.56 | 13.80 | 13.74 | 13.67 | 13.57 | 13.53 | 13.50 | 13.49 | 2.56 |
| 2.57 | 13.88 | 13.83 | 13.75 | 13.65 | 13.61 | 13.58 | 13.56 | 2.57 |
| 2.58 | 13.97 | 13.91 | 13.83 | 13.74 | 13.69 | 13.66 | 13.64 | 2.58 |
| 2.59 | 14.05 | 13.99 | 13.91 | 13.82 | 13.77 | 13.74 | 13.72 | 2.59 |
| 2.60 | 14.13 | 14.07 | 13.99 | 13.90 | 13.85 | 13.82 | 13.80 | 2.60 |
| 2.61 | 14.21 | 14.16 | 14.08 | 13.99 | 13.93 | 13.90 | 13.88 | 2.61 |
| 2.62 | 14.29 | 14.25 | 14.15 | 14.07 | 14.01 | 13.98 | 13.96 | 2.62 |
| 2.63 | 14.37 | 14.34 | 14.24 | 14.15 | 14.09 | 14.06 | 14.04 | 2.63 |
| 2.64 | 14.45 | 14.42 | 14.32 | 14.23 | 14.17 | 14.14 | 14.12 | 2.64 |
| 2.65 | 14.54 | 14.50 | 14.40 | 14.32 | 14.25 | 14.22 | 14.20 | 2.65 |
| 2.66 | 14.63 | 14.59 | 14.49 | 14.41 | 14.33 | 14.30 | 14.28 | 2.66 |
| 2.67 | 14.71 | 14.68 | 14.57 | 14.49 | 14.41 | 14.38 | 14.36 | 2.67 |
| 2.68 | 14.79 | 14.76 | 14.65 | 14.57 | 14.49 | 14.46 | 14.44 | 2.68 |
| 2.69 | 14.88 | 14.84 | 14.73 | 14.65 | 14.57 | 14.54 | 14.52 | 2.69 |
| 2.70 | 14.96 | 14.92 | 14.82 | 14.73 | 14.65 | 14.61 | 14.60 | 2.70 |
| 2.71 | 15.05 | 15.02 | 14.90 | 14.82 | 14.73 | 14.69 | 14.68 | 2.71 |
| 2.72 | 15.13 | 15.09 | 14.99 | 14.90 | 14.84 | 14.77 | 14.76 | 2.72 |
| 2.73 | 15.21 | 15.18 | 15.08 | 14.98 | 14.89 | 14.85 | 14.85 | 2.73 |
| 2.74 | 15.29 | 15.26 | 15.16 | 15.06 | 14.98 | 14.94 | 14.92 | 2.74 |
| 2.75 | 15.38 | 15.34 | 15.24 | 15.14 | 15.06 | 15.02 | 15.00 | 2.75 |
| 2.76 | 15.47 | 15.43 | 15.33 | 15.22 | 15.14 | 15.10 | 15.08 | 2.76 |
| 2.77 | 15.56 | 15.51 | 15.40 | 15.30 | 15.22 | 15.18 | 15.17 | 2.77 |
| 2.78 | 15.65 | 15.59 | 15.49 | 15.38 | 15.31 | 15.27 | 15.25 | 2.78 |
| 2.79 | 15.74 | 15.68 | 15.58 | 15.46 | 15.40 | 15.36 | 15.34 | 2.79 |
| 2.80 | 15.83 | 15.76 | 15.66 | 15.54 | 15.48 | 15.44 | 15.42 | 2.80 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 2.81 | 18.33 | 17.42 | 16.88 | 16.53 | 16.30 | 16.12 | 16.00 | 2.81 |
| 2.82 | 18.44 | 17.52 | 16.98 | 16.62 | 16.39 | 16.21 | 16.08 | 2.82 |
| 2.83 | 18.54 | 17.62 | 17.07 | 16.71 | 16.48 | 16.30 | 16.17 | 2.83 |
| 2.84 | 18.65 | 17.72 | 17.17 | 16.80 | 16.57 | 16.39 | 16.26 | 2.84 |
| 2.85 | 18.75 | 17.82 | 17.27 | 16.89 | 16.66 | 16.48 | 16.35 | 2.85 |
| 2.86 | 18.86 | 17.92 | 17.37 | 16.99 | 16.75 | 16.57 | 16.43 | 2.86 |
| 2.87 | 18.97 | 18.02 | 17.47 | 17.08 | 16.84 | 16.66 | 16.52 | 2.87 |
| 2.88 | 19.08 | 18.12 | 17.57 | 17.17 | 16.93 | 16.75 | 16.61 | 2.88 |
| 2.89 | 19.18 | 18.22 | 17.67 | 17.26 | 17.02 | 16.84 | 16.70 | 2.89 |
| 2.90 | 19.29 | 18.32 | 17.77 | 17.36 | 17.11 | 16.93 | 16.79 | 2.90 |
| 2.91 | 19.40 | 18.43 | 17.86 | 17.45 | 17.20 | 17.02 | 16.88 | 2.91 |
| 2.92 | 19.51 | 18.53 | 17.96 | 17.55 | 17.29 | 17.11 | 16.97 | 2.92 |
| 2.93 | 19.62 | 18.63 | 18.06 | 17.65 | 17.39 | 17.20 | 17.06 | 2.93 |
| 2.94 | 19.73 | 18.73 | 18.15 | 17.75 | 17.49 | 17.30 | 17.15 | 2.94 |
| 2.95 | 19.83 | 18.83 | 18.25 | 17.84 | 17.59 | 17.39 | 17.24 | 2.95 |
| 2.96 | 19.94 | 18.94 | 18.35 | 17.94 | 17.69 | 17.49 | 17.33 | 2.96 |
| 2.97 | 20.05 | 19.04 | 18.45 | 18.04 | 17.78 | 17.58 | 17.42 | 2.97 |
| 2.98 | 20.16 | 19.15 | 18.54 | 18.14 | 17.87 | 17.67 | 17.51 | 2.98 |
| 2.99 | 20.27 | 19.25 | 18.64 | 18.23 | 17.96 | 17.76 | 17.61 | 2.99 |
| 3.00 | 20.39 | 19.36 | 18.74 | 18.33 | 18.06 | 17.86 | 17.71 | 3.00 |
| 3.01 | 20.50 | 19.46 | 18.84 | 18.43 | 18.15 | 17.95 | 17.80 | 3.01 |
| 3.02 | 20.61 | 19.57 | 18.94 | 18.52 | 18.25 | 18.04 | 17.89 | 3.02 |
| 3.03 | 20.72 | 19.67 | 19.04 | 18.62 | 18.34 | 18.13 | 17.98 | 3.03 |
| 3.04 | 20.83 | 19.77 | 19.14 | 18.71 | 18.44 | 18.22 | 18.07 | 3.04 |
| 3.05 | 20.94 | 19.88 | 19.24 | 18.81 | 18.53 | 18.32 | 18.16 | 3.05 |
| 3.06 | 21.05 | 19.98 | 19.34 | 18.91 | 18.63 | 18.41 | 18.25 | 3.06 |
| 3.07 | 21.16 | 20.08 | 19.44 | 19.01 | 18.73 | 18.50 | 18.35 | 3.07 |
| 3.08 | 21.27 | 20.18 | 19.54 | 19.11 | 18.83 | 18.60 | 18.45 | 3.08 |
| 3.09 | 21.39 | 20.29 | 19.64 | 19.21 | 18.92 | 18.69 | 18.54 | 3.09 |
| 3.10 | 21.50 | 20.40 | 19.74 | 19.31 | 19.02 | 18.79 | 18.64 | 3.10 |
| 3.11 | 21.61 | 20.51 | 19.85 | 19.41 | 19.11 | 18.89 | 18.74 | 3.11 |
| 3.12 | 21.72 | 20.62 | 19.95 | 19.51 | 19.20 | 18.98 | 18.83 | 3.12 |
| 3.13 | 21.83 | 20.73 | 20.05 | 19.60 | 19.30 | 19.08 | 18.92 | 3.13 |
| 3.14 | 21.94 | 20.83 | 20.15 | 19.70 | 19.40 | 19.17 | 19.01 | 3.14 |
| 3.15 | 22.05 | 20.94 | 20.25 | 19.80 | 19.50 | 19.27 | 19.10 | 3.15 |
| 3.16 | 22.17 | 21.05 | 20.35 | 19.90 | 19.60 | 19.37 | 19.20 | 3.16 |
| 3.17 | 22.29 | 21.16 | 20.46 | 20.00 | 19.70 | 19.46 | 19.30 | 3.17 |
| 3.18 | 22.40 | 21.27 | 20.56 | 20.10 | 19.80 | 19.56 | 19.39 | 3.18 |
| 3.19 | 22.52 | 21.37 | 20.66 | 20.20 | 19.89 | 19.65 | 19.49 | 3.19 |
| 3.20 | 22.64 | 21.48 | 20.77 | 20.31 | 19.98 | 19.75 | 19.58 | 3.20 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. $Q$ Cu. Ft. per Sec. | $p=10$ Ft. $Q$ Cu. Ft. per Sec. | $p=12$ Ft. $Q$ Cu. Ft. per Sec. | $p=16$ Ft. $Q$ Cu. Ft. per Sec. | $p=20$ Ft. $Q$ Cu. Ft. per Sec. | $p=25$ Ft. $Q$ Cu. Ft. per Sec. | $p=30$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet |
|---|---|---|---|---|---|---|---|---|
| 2.81 | 15.91 | 15.85 | 15.75 | 15.63 | 15.57 | 15.53 | 15.50 | 2.81 |
| 2.82 | 16.00 | 15.93 | 15.83 | 15.72 | 15.66 | 15.62 | 15.58 | 2.82 |
| 2.83 | 16.09 | 16.02 | 15.92 | 15.80 | 15.74 | 15.70 | 15.67 | 2.83 |
| 2.84 | 16.18 | 16.11 | 16.00 | 15.88 | 15.83 | 15.78 | 15.75 | 2.84 |
| 2.85 | 16.26 | 16.19 | 16.09 | 15.97 | 15.91 | 15.87 | 15.84 | 2.85 |
| 2.86 | 16.35 | 16.28 | 16.18 | 16.05 | 16.00 | 15.95 | 15.92 | 2.86 |
| 2.87 | 16.43 | 16.37 | 16.26 | 16.13 | 16.09 | 16.03 | 16.01 | 2.87 |
| 2.88 | 16.52 | 16.46 | 16.34 | 16.22 | 16.17 | 16.12 | 16.09 | 2.88 |
| 2.89 | 16.61 | 16.54 | 16.43 | 16.30 | 16.25 | 16.20 | 16.17 | 2.89 |
| 2.90 | 16.70 | 16.63 | 16.51 | 16.38 | 16.33 | 16.28 | 16.25 | 2.90 |
| 2.91 | 16.78 | 16.72 | 16.60 | 16.47 | 16.42 | 16.37 | 16.34 | 2.91 |
| 2.92 | 16.87 | 16.80 | 16.68 | 16.56 | 16.50 | 16.45 | 16.43 | 2.92 |
| 2.93 | 16.96 | 16.88 | 16.76 | 16.64 | 16.58 | 16.53 | 16.50 | 2.93 |
| 2.94 | 17.04 | 16.97 | 16.85 | 16.72 | 16.66 | 16.61 | 16.58 | 2.94 |
| 2.95 | 17.13 | 17.06 | 16.94 | 16.81 | 16.75 | 16.70 | 16.67 | 2.95 |
| 2.96 | 17.23 | 17.15 | 17.03 | 16.89 | 16.84 | 16.79 | 16.75 | 2.96 |
| 2.97 | 17.32 | 17.24 | 17.11 | 16.98 | 16.92 | 16.87 | 16.84 | 2.97 |
| 2.98 | 17.41 | 17.33 | 17.20 | 17.07 | 17.00 | 16.95 | 16.92 | 2.98 |
| 2.99 | 17.50 | 17.42 | 17.28 | 17.16 | 17.09 | 17.04 | 17.01 | 2.99 |
| 3.00 | 17.60 | 17.52 | 17.39 | 17.25 | 17.18 | 17.13 | 17.10 | 3.00 |
| 3.01 | 17.69 | 17.61 | 17.47 | 17.33 | 17.26 | 17.21 | 17.18 | 3.01 |
| 3.02 | 17.78 | 17.70 | 17.55 | 17.42 | 17.34 | 17.30 | 17.26 | 3.02 |
| 3.03 | 17.87 | 17.79 | 17.64 | 17.51 | 17.43 | 17.38 | 17.35 | 3.03 |
| 3.04 | 17.96 | 17.88 | 17.73 | 17.59 | 17.52 | 17.47 | 17.44 | 3.04 |
| 3.05 | 18.05 | 17.97 | 17.82 | 17.68 | 17.61 | 17.56 | 17.52 | 3.05 |
| 3.06 | 18.14 | 18.06 | 17.91 | 17.77 | 17.70 | 17.65 | 17.61 | 3.06 |
| 3.07 | 18.23 | 18.15 | 18.00 | 17.86 | 17.78 | 17.74 | 17.70 | 3.07 |
| 3.08 | 18.33 | 18.24 | 18.09 | 17.95 | 17.87 | 17.83 | 17.79 | 3.08 |
| 3.09 | 18.42 | 18.33 | 18.18 | 18.03 | 17.95 | 17.92 | 17.88 | 3.09 |
| 3.10 | 18.51 | 18.42 | 18.27 | 18.12 | 18.04 | 18.01 | 17.96 | 3.10 |
| 3.11 | 18.60 | 18.50 | 18.36 | 18.21 | 18.13 | 18.09 | 18.05 | 3.11 |
| 3.12 | 18.69 | 18.59 | 18.45 | 18.29 | 18.22 | 18.18 | 18.13 | 3.12 |
| 3.13 | 18.78 | 18.68 | 18.54 | 18.38 | 18.31 | 18.27 | 18.22 | 3.13 |
| 3.14 | 18.87 | 18.77 | 18.63 | 18.47 | 18.40 | 18.35 | 18.30 | 3.14 |
| 3.15 | 18.96 | 18.87 | 18.72 | 18.56 | 18.49 | 18.44 | 18.38 | 3.15 |
| 3.16 | 19.06 | 18.96 | 18.81 | 18.65 | 18.57 | 18.53 | 18.48 | 3.16 |
| 3.17 | 19.15 | 19.05 | 18.90 | 18.74 | 18.66 | 18.62 | 18.56 | 3.17 |
| 3.18 | 19.25 | 19.14 | 18.99 | 18.83 | 18.75 | 18.70 | 18.65 | 3.18 |
| 3.19 | 19.35 | 19.24 | 19.09 | 18.92 | 18.84 | 18.78 | 18.74 | 3.19 |
| 3.20 | 19.45 | 19.34 | 19.19 | 19.02 | 18.93 | 18.87 | 18.83 | 3.20 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet.
Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. | $p=3$ Ft. | $p=4$ Ft | $p=5$ Ft. | $p=6$ Ft. | $p=7$ Ft. | $p=8$ Ft. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu Ft. per Sec | $Q$ Cu Ft. per Sec. | |
| 3.21 | 22.76 | 21.59 | 20.87 | 20.41 | 20.08 | 19.84 | 19.68 | 3.21 |
| 3.22 | 22.88 | 21.70 | 20.97 | 20.51 | 20.18 | 19.94 | 19.78 | 3.22 |
| 3.23 | 22.99 | 21.81 | 21.07 | 20.61 | 20.28 | 20.04 | 19.87 | 3.23 |
| 3.24 | 23.11 | 21.92 | 21.18 | 20.71 | 20.38 | 20.13 | 19.97 | 3.24 |
| 3.25 | 23.23 | 22.03 | 21.28 | 20.81 | 20.48 | 20.23 | 20.06 | 3.25 |
| 3.26 | 23.35 | 22.14 | 21.38 | 20.91 | 20.58 | 20.33 | 20.16 | 3.26 |
| 3.27 | 23.47 | 22.25 | 21.49 | 21.01 | 20.68 | 20.42 | 20.26 | 3.27 |
| 3.28 | 23.58 | 22.36 | 21.59 | 21.12 | 20.78 | 20.52 | 20.35 | 3.28 |
| 3.29 | 23.69 | 22.47 | 21.69 | 21.22 | 20.88 | 20.62 | 20.45 | 3.29 |
| 3.30 | 23.81 | 22.59 | 21.80 | 21.33 | 20.98 | 20.71 | 20.55 | 3.30 |
| 3.31 | 23.93 | 22.70 | 21.90 | 21.43 | 21.08 | 20.81 | 20.65 | 3.31 |
| 3.32 | 24.05 | 22.81 | 22.01 | 21.53 | 21.18 | 20.91 | 20.75 | 3.32 |
| 3.33 | 24.17 | 22.92 | 22.12 | 21.63 | 21.28 | 21.01 | 20.85 | 3.33 |
| 3.34 | 24.28 | 23.03 | 22.23 | 21.74 | 21.38 | 21.11 | 20.94 | 3.34 |
| 3.35 | 24.40 | 23.14 | 22.34 | 21.84 | 21.48 | 21.21 | 21.04 | 3.35 |
| 3.36 | 24.52 | 23.26 | 22.45 | 21.94 | 21.58 | 21.31 | 21.13 | 3.36 |
| 3.37 | 24.64 | 23.37 | 22.56 | 22.04 | 21.68 | 21.41 | 21.23 | 3.37 |
| 3.38 | 24.75 | 23.48 | 22.67 | 22.15 | 21.78 | 21.51 | 21.32 | 3.38 |
| 3.39 | 24.86 | 23.59 | 22.78 | 22.25 | 21.88 | 21.61 | 21.47 | 3.39 |
| 3.40 | 24.98 | 23.70 | 22.89 | 22.36 | 21.99 | 21.72 | 21.52 | 3.40 |
| 3.41 | 25.10 | 23.82 | 23.00 | 22.47 | 22.09 | 21.82 | 21.61 | 3.41 |
| 3.42 | 25.22 | 23.93 | 23.11 | 22.58 | 22.19 | 21.92 | 21.71 | 3.42 |
| 3.43 | 25.34 | 24.04 | 23.22 | 22.69 | 22.29 | 22.02 | 21.80 | 3.43 |
| 3.44 | 25.46 | 24.15 | 23.33 | 22.79 | 22.39 | 22.12 | 21.89 | 3.44 |
| 3.45 | 25.58 | 24.26 | 23.44 | 22.89 | 22.49 | 22.22 | 21.99 | 3.45 |
| 3.46 | 25.70 | 24.37 | 23.55 | 23.00 | 22.60 | 22.32 | 22.09 | 3.46 |
| 3.47 | 25.82 | 24.49 | 23.66 | 23.11 | 22.70 | 22.42 | 22.18 | 3.47 |
| 3.48 | 25.94 | 24.60 | 23.77 | 23.22 | 22.80 | 22.52 | 22.28 | 3.48 |
| 3.49 | 26.07 | 24.72 | 23.88 | 23.33 | 22.91 | 22.62 | 22.38 | 3.49 |
| 3.50 | 26.20 | 24.83 | 24.00 | 23.43 | 23.01 | 22.73 | 22.48 | 3.50 |
| 3.51 | 26.31 | 24.95 | 24.10 | 23.54 | 23.12 | 22.83 | 22.58 | 3.51 |
| 3.52 | 26.43 | 25.07 | 24.21 | 23.64 | 23.22 | 22.93 | 22.69 | 3.52 |
| 3.53 | 26.55 | 25.18 | 24.32 | 23.75 | 28.33 | 23.03 | 22.79 | 3.53 |
| 3.54 | 26.66 | 25.29 | 24.43 | 23.85 | 23.44 | 23.13 | 22.90 | 3.54 |
| 3.55 | 26.78 | 25.41 | 24.54 | 23.96 | 23.55 | 23.23 | 23.00 | 3.55 |
| 3.56 | 26 90 | 25.52 | 24.65 | 24.07 | 23.65 | 23.33 | 23.10 | 3.56 |
| 3 57 | 27.02 | 25.64 | 24.76 | 24.18 | 23.75 | 23.43 | 23.20 | 3.57 |
| 3.58 | 27.15 | 25.76 | 24.87 | 24.29 | 23.85 | 23.54 | 23.30 | 3.58 |
| 3.59 | 27.28 | 25.87 | 24.98 | 24.39 | 23.96 | 23.64 | 23.41 | 3.59 |
| 3.60 | 27.41 | 25.99 | 25.09 | 24.49 | 24.06 | 23.75 | 23.52 | 3.60 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. | $p=10$ Ft | $p=12$ Ft. | $p=16$ Ft. | $p=20$ Ft. | $p=25$ Ft. | $p=30$ Ft. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | |
| 3.21 | 19.54 | 19.43 | 19.28 | 19.11 | 19.02 | 18.96 | 18.92 | 3.21 |
| 3.22 | 19.63 | 19.52 | 19.37 | 19.20 | 19.11 | 19.05 | 19.00 | 3.22 |
| 3.23 | 19.73 | 19.61 | 19.46 | 19.29 | 19.19 | 19.13 | 19.09 | 3.23 |
| 3.24 | 19.82 | 19.70 | 19.55 | 19.38 | 19.28 | 19.22 | 19.18 | 3.24 |
| 3.25 | 19.92 | 19.80 | 19.64 | 19.48 | 19.37 | 19.31 | 19.27 | 3.25 |
| 3.26 | 20.02 | 19.89 | 19.74 | 19.57 | 19.46 | 19.40 | 19.36 | 3.26 |
| 3.27 | 20.12 | 19.98 | 19.83 | 19.66 | 19.55 | 19.49 | 19.45 | 3.27 |
| 3.28 | 20.22 | 20.08 | 19 93 | 19.75 | 19.64 | 19.58 | 19.54 | 3.28 |
| 3.29 | 20.31 | 20.17 | 20.02 | 19.84 | 19.73 | 19.67 | 19.63 | 3.29 |
| 3.30 | 20.41 | 20.27 | 20.11 | 19.93 | 19.82 | 19.76 | 19.73 | 3.30 |
| 3.31 | 20.50 | 20.36 | 20.20 | 20.03 | 19.91 | 19.85 | 19.82 | 3.31 |
| 3.32 | 20.60 | 20.45 | 20.29 | 20.12 | 20.00 | 19.93 | 19.91 | 3.32 |
| 3.33 | 20.70 | 20.55 | 20.39 | 20.21 | 20.09 | 20.02 | 20.00 | 3.33 |
| 3.34 | 20.79 | 20.64 | 20.48 | 20.30 | 20.18 | 20.12 | 20.09 | 3.34 |
| 3.35 | 20.89 | 20.74 | 20.58 | 20 39 | 20.27 | 20.21 | 20.18 | 3.35 |
| 3.36 | 20.99 | 20.85 | 20.67 | 20.48 | 20.36 | 20.31 | 20.27 | 3.36 |
| 3.37 | 21.09 | 20.94 | 20.77 | 20.58 | 20.46 | 20.40 | 20.36 | 3.37 |
| 3.38 | 21.18 | 21.04 | 20.86 | 20.67 | 20.56 | 20.49 | 20.45 | 3.38 |
| 3.39 | 21.27 | 21.14 | 20.96 | 20.76 | 20.65 | 20.58 | 20.54 | 3.39 |
| 3.40 | 21.36 | 21.24 | 21.06 | 20.86 | 20.75 | 20.68 | 20.63 | 3.40 |
| 3.41 | 21.46 | 21.33 | 21.15 | 20.95 | 20.85 | 20 78 | 20.72 | 3.41 |
| 3.42 | 21.56 | 21.42 | 21.24 | 21.05 | 20.94 | 20.88 | 20.81 | 3.42 |
| 3.43 | 21 66 | 21.52 | 21.34 | 21.15 | 21.03 | 20.98 | 20.90 | 3.43 |
| 3.44 | 21.76 | 21.62 | 21.43 | 21.24 | 21.12 | 21.07 | 21.00 | 3.44 |
| 3.45 | 21.86 | 21.72 | 21.52 | 21.34 | 21.21 | 21.16 | 21.10 | 3.45 |
| 3.46 | 21.96 | 21.82 | 21 62 | 21.43 | 21.31 | 21.26 | 21.20 | 3.46 |
| 3.47 | 22.06 | 21.92 | 21.72 | 21.53 | 21.40 | 21.35 | 21.30 | 3.47 |
| 3.48 | 22.16 | 22.02 | 21.82 | 21.63 | 21.50 | 21.44 | 21.40 | 3.48 |
| 3.49 | 22.27 | 22 12 | 21.91 | 21.73 | 21.59 | 21.53 | 21.50 | 3.49 |
| 3.50 | 22.38 | 22.22 | 22.00 | 21.83 | 21.69 | 21.62 | 21.60 | 3.50 |
| 3.51 | 22.47 | 22.31 | 22 10 | 21.92 | 21.78 | 21.71 | 21.68 | 3.51 |
| 3.52 | 22.56 | 22.41 | 22.19 | 22.01 | 21.87 | 21.80 | 21.76 | 3.52 |
| 3.53 | 22.66 | 22.51 | 22.28 | 22.10 | 21.96 | 21.89 | 21.85 | 3.53 |
| 3.54 | 22.75 | 22.60 | 22.38 | 22.19 | 22.05 | 21.98 | 21.94 | 3.54 |
| 3.55 | 22.85 | 22.70 | 22.48 | 22.28 | 22.15 | 22.07 | 22.03 | 3.55 |
| 3.56 | 22.95 | 22.80 | 22.58 | 22.38 | 22.25 | 22.16 | 22.12 | 3.56 |
| 3.57 | 23.05 | 22.91 | 22.68 | 22.48 | 22.34 | 22.26 | 22.21 | 3.57 |
| 3.58 | 23.15 | 23.01 | 22.78 | 22.57 | 22.43 | 22.35 | 22.30 | 3.58 |
| 3.59 | 23 25 | 23.10 | 22.88 | 22.66 | 22.52 | 22.44 | 22.39 | 3.59 |
| 3.60 | 23.34 | 23.20 | 22.99 | 22.75 | 22.62 | 22.53 | 22.48 | 3.60 |

DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet.
Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 3.61 | 27.53 | 26.11 | 25.20 | 24.60 | 24.17 | 23.86 | 23.62 | 3.61 |
| 3.62 | 27.65 | 26.23 | 25.31 | 24.71 | 24.28 | 23.96 | 23.73 | 3.62 |
| 3.63 | 27.77 | 26.35 | 25.42 | 24.82 | 24.38 | 24.07 | 23.83 | 3.63 |
| 3.64 | 27.89 | 26.46 | 25.53 | 24.93 | 24.49 | 24.17 | 23.93 | 3.64 |
| 3.65 | 28.02 | 26.58 | 25.64 | 25.04 | 24.60 | 24.27 | 24.03 | 3.65 |
| 3.66 | 28.15 | 26.70 | 25.76 | 25.15 | 24.71 | 24.38 | 24.14 | 3.66 |
| 3.67 | 28.27 | 26.82 | 25.87 | 25.26 | 24.82 | 24.48 | 24.25 | 3.67 |
| 3.68 | 28.39 | 26.94 | 25.99 | 25.37 | 24.92 | 24.59 | 24.35 | 3.68 |
| 3.69 | 28.52 | 27.06 | 26.10 | 25.48 | 25.03 | 24.70 | 24.46 | 3.69 |
| 3.70 | 28.64 | 27.17 | 26.22 | 25.59 | 25.14 | 24.80 | 24.56 | 3.70 |
| 3.71 | 28.77 | 27.29 | 26.33 | 25.70 | 25.25 | 24.91 | 24.67 | 3.71 |
| 3.72 | 28.90 | 27.41 | 26.45 | 25.81 | 25.35 | 25.01 | 24.78 | 3.72 |
| 3.73 | 29.03 | 27.58 | 26.57 | 25.92 | 25.46 | 25.11 | 24.88 | 3.73 |
| 3.74 | 29.16 | 27.65 | 26.68 | 26.04 | 25.57 | 25.22 | 24.98 | 3.74 |
| 3.75 | 29.29 | 27.77 | 26.79 | 26.15 | 25.68 | 25.33 | 25.08 | 3.75 |
| 3.76 | 29.42 | 27.90 | 26.90 | 26.26 | 25.79 | 25.43 | 25.18 | 3.76 |
| 3.77 | 29.55 | 28.02 | 27.02 | 26.37 | 25.89 | 25.54 | 25.29 | 3.77 |
| 3.78 | 29.68 | 28.14 | 27.14 | 26.48 | 26.00 | 25.64 | 25.39 | 3.78 |
| 3.79 | 29.81 | 28.26 | 27.26 | 26.59 | 26.11 | 25.75 | 25.50 | 3.79 |
| 3.80 | 29.94 | 28.38 | 27.38 | 26.70 | 26.22 | 25.87 | 25.60 | 3.80 |
| 3.81 | 30.07 | 28.50 | 27.49 | 26.82 | 26.33 | 25.97 | 25.71 | 3.81 |
| 3.82 | 30.19 | 28.62 | 27.60 | 26.93 | 26.44 | 26.07 | 25.82 | 3.82 |
| 3.83 | 30.32 | 28.74 | 27.72 | 27.04 | 26.55 | 26.17 | 25.92 | 3.83 |
| 3.84 | 30.44 | 28.86 | 27.84 | 27.15 | 26.67 | 26.27 | 26.02 | 3.84 |
| 3.85 | 30.57 | 28.98 | 27.95 | 27.26 | 26.78 | 26.38 | 26.13 | 3.85 |
| 3.86 | 30.70 | 29.11 | 28.07 | 27.38 | 26.89 | 26.49 | 26.23 | 3.86 |
| 3.87 | 30.82 | 29.23 | 28.18 | 27.50 | 27.00 | 26.60 | 26.34 | 3.87 |
| 3.88 | 30.95 | 29.35 | 28.30 | 27.62 | 27.11 | 26.71 | 26.44 | 3.88 |
| 3.89 | 31.08 | 29.48 | 28.42 | 27.73 | 27.22 | 26.82 | 26.55 | 3.89 |
| 3.90 | 31.21 | 29.60 | 28.53 | 27.84 | 27.33 | 26.93 | 26.65 | 3.90 |
| 3.91 | 31.34 | 29.73 | 28.65 | 27.95 | 27.44 | 27.03 | 26.76 | 3.91 |
| 3.92 | 31.47 | 29.85 | 28.77 | 28.06 | 27.55 | 27.14 | 26.86 | 3.92 |
| 3.93 | 31.60 | 29.97 | 28.89 | 28.17 | 27.66 | 27.25 | 26.97 | 3.93 |
| 3.94 | 31.73 | 30.10 | 29.01 | 28.28 | 27.77 | 27.36 | 27.08 | 3.94 |
| 3.95 | 31.86 | 30.22 | 29.13 | 28.40 | 27.88 | 27.47 | 27.19 | 3.95 |
| 3.96 | 31.99 | 30.34 | 29.25 | 28.51 | 27.99 | 27.59 | 27.30 | 3.96 |
| 3.97 | 32.12 | 30.46 | 29.38 | 28.63 | 28.10 | 27.70 | 27.41 | 3.97 |
| 3.98 | 32.26 | 30.59 | 29.50 | 28.75 | 28.21 | 27.82 | 27.52 | 3.98 |
| 3.99 | 32.40 | 30.71 | 29.62 | 28.87 | 28.33 | 27.93 | 27.63 | 3.99 |
| 4.00 | 32.54 | 30.84 | 29.74 | 28.99 | 28.45 | 28.05 | 27.74 | 4.00 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. $Q$ Cu. Ft. per Sec. | $p=10$ Ft. $Q$ Cu. Ft. per Sec. | $p=12$ Ft. $Q$ Cu. Ft. per Sec | $p=16$ Ft. $Q$ Cu. Ft. per Sec. | $p=20$ Ft. $Q$ Cu. Ft. per Sec. | $p=25$ Ft. $Q$ Cu. Ft. per Sec. | $p=30$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 3.61 | 23.45 | 23.30 | 23.08 | 22.85 | 22.72 | 22.63 | 22.58 | 3.61 |
| 3.62 | 23.55 | 23.40 | 23.17 | 22.95 | 22.82 | 22.72 | 22.68 | 3.62 |
| 3.63 | 23.65 | 23.50 | 23.26 | 23.05 | 22.91 | 22.81 | 22.78 | 3.63 |
| 3.64 | 23.75 | 23.60 | 23.36 | 23.15 | 23.01 | 22.91 | 22.88 | 3.64 |
| 3.65 | 23.85 | 23.70 | 23.46 | 23.24 | 23.10 | 23.01 | 22.97 | 3.65 |
| 3.66 | 23.95 | 23.80 | 23.56 | 23.34 | 23.20 | 23.11 | 23.06 | 3.66 |
| 3.67 | 24.05 | 23.90 | 23.65 | 23.44 | 23.30 | 23.20 | 23.15 | 3.67 |
| 3.68 | 24.15 | 24.00 | 23.75 | 23.53 | 23.40 | 23.29 | 23.24 | 3.68 |
| 3.69 | 24.25 | 24.10 | 23.85 | 23.63 | 23.49 | 23.38 | 23.34 | 3.69 |
| 3.70 | 24.35 | 24.20 | 23.95 | 23.73 | 23.59 | 23.48 | 23.43 | 3.70 |
| 3.71 | 24.45 | 24.30 | 24.05 | 23.83 | 23.68 | 23.58 | 23.53 | 3.71 |
| 3.72 | 24.55 | 24.40 | 24.15 | 23.92 | 23.78 | 23.67 | 23.63 | 3.72 |
| 3.73 | 24.65 | 24.50 | 24.25 | 24.02 | 23.87 | 23.77 | 23.72 | 3.73 |
| 3.74 | 24.75 | 24.60 | 24.35 | 24.12 | 23.96 | 23.86 | 23.82 | 3.74 |
| 3.75 | 24.86 | 24.70 | 24.46 | 24.22 | 24.06 | 23.95 | 23.91 | 3.75 |
| 3.76 | 24.96 | 24.81 | 24.57 | 24.32 | 24.16 | 24.05 | 24.00 | 3.76 |
| 3.77 | 25.07 | 24.92 | 24.67 | 24.41 | 24.26 | 24.15 | 24.09 | 3.77 |
| 3.78 | 25.17 | 25.02 | 24.78 | 24.51 | 24.36 | 24.25 | 24.19 | 3.78 |
| 3.79 | 25.28 | 25.12 | 24.88 | 24.61 | 24.46 | 24.35 | 24.29 | 3.79 |
| 3.80 | 25.39 | 25.23 | 24.99 | 24.71 | 24.56 | 24.45 | 24.39 | 3.80 |
| 3.81 | 25.49 | 25.33 | 25.09 | 24.81 | 24.65 | 24.55 | 24.48 | 3.81 |
| 3.82 | 25.59 | 25.43 | 25.19 | 24.90 | 24.75 | 24.64 | 24.57 | 3.82 |
| 3.83 | 25.69 | 25.53 | 25.29 | 25.00 | 24.85 | 24.74 | 24.66 | 3.83 |
| 3.84 | 25.79 | 25.63 | 25.39 | 25.10 | 24.95 | 24.84 | 24.76 | 3.84 |
| 3.85 | 25.90 | 25.73 | 25.49 | 25.20 | 25.05 | 24.93 | 24.85 | 3.85 |
| 3.86 | 26.01 | 25.84 | 25.59 | 25.30 | 25.14 | 25.03 | 24.95 | 3.86 |
| 3.87 | 26.12 | 25.94 | 25.70 | 25.40 | 25.24 | 25.12 | 25.05 | 3.87 |
| 3.88 | 26.22 | 26.05 | 25.80 | 25.50 | 25.34 | 25.22 | 25.15 | 3.88 |
| 3.89 | 26.32 | 26.15 | 25.90 | 25.60 | 25.43 | 25.32 | 25.24 | 3.89 |
| 3.90 | 26.43 | 26.26 | 26.01 | 25.70 | 25.53 | 25.42 | 25.34 | 3.90 |
| 3.91 | 26.53 | 26.36 | 26.11 | 25.80 | 25.63 | 25.51 | 25.43 | 3.91 |
| 3.92 | 26.64 | 26.47 | 26.21 | 25.90 | 25.73 | 25.61 | 25.53 | 3.92 |
| 3.93 | 26.74 | 26.57 | 26.31 | 26.00 | 25.84 | 25.71 | 25.63 | 3.93 |
| 3.94 | 26.85 | 26.67 | 26.42 | 26.10 | 25.94 | 25.81 | 25.73 | 3.94 |
| 3.95 | 26.96 | 26.78 | 26.52 | 26.20 | 26.04 | 25.91 | 25.83 | 3.95 |
| 3.96 | 27.07 | 26.89 | 26.63 | 26.30 | 26.14 | 26.01 | 25.93 | 3.96 |
| 3.97 | 27.18 | 26.99 | 26.74 | 26.40 | 26.24 | 26.11 | 26.04 | 3.97 |
| 3.98 | 27.29 | 27.10 | 26.84 | 26.50 | 26.34 | 26.22 | 26.14 | 3.98 |
| 3.99 | 27.40 | 27.21 | 26.94 | 26.60 | 26.44 | 26.32 | 26.25 | 3.99 |
| 4.00 | 27.51 | 27.32 | 27.05 | 26.72 | 26.55 | 26.42 | 26.35 | 4.00 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 4.01 | 32.67 | 30.97 | 29.86 | 29.11 | 28.55 | 28.16 | 27.84 | 4.01 |
| 4.02 | 32.80 | 31.10 | 29.98 | 29.22 | 28.66 | 28.27 | 27.95 | 4.02 |
| 4.03 | 32.93 | 31.23 | 30.10 | 29.34 | 28.78 | 28.38 | 28.06 | 4.03 |
| 4.04 | 33.06 | 31.35 | 30.22 | 29.45 | 28.89 | 28.49 | 28.17 | 4.04 |
| 4.05 | 33.19 | 31.48 | 30.34 | 29.57 | 29.01 | 28.60 | 28.28 | 4.05 |
| 4.06 | 33.33 | 31.61 | 30.46 | 29.68 | 29.13 | 28.72 | 28.39 | 4.06 |
| 4.07 | 33.46 | 31.74 | 30.58 | 29.80 | 29.24 | 28.83 | 28.50 | 4.07 |
| 4.08 | 33.59 | 31.87 | 30.70 | 29.92 | 29.36 | 28.95 | 28.61 | 4.08 |
| 4.09 | 33.72 | 31.99 | 30.83 | 30.04 | 29.48 | 29.06 | 28.72 | 4.09 |
| 4.10 | 33.85 | 32.12 | 30.95 | 30.15 | 29.59 | 29.17 | 28.83 | 4.10 |
| 4.11 | 33.99 | 32.25 | 31.08 | 30.27 | 29.71 | 29.28 | 28.94 | 4.11 |
| 4.12 | 34.13 | 32.38 | 31.20 | 30.38 | 29.83 | 29.40 | 29.05 | 4.12 |
| 4.13 | 34.26 | 32.50 | 31.32 | 30.50 | 29.94 | 29.51 | 29.16 | 4.13 |
| 4.14 | 34.39 | 32.63 | 31.45 | 30.62 | 30.05 | 29.62 | 29.28 | 4.14 |
| 4.15 | 34.52 | 32.75 | 31.57 | 30.74 | 30.17 | 29.74 | 29.40 | 4.15 |
| 4.16 | 34.66 | 32.88 | 31.69 | 30.86 | 30.29 | 29.85 | 29.51 | 4.16 |
| 4.17 | 34.80 | 33.00 | 31.82 | 30.98 | 30.40 | 29.96 | 29.62 | 4.17 |
| 4.18 | 34.94 | 33.13 | 31.94 | 31.10 | 30.52 | 30.06 | 29.74 | 4.18 |
| 4.19 | 35.08 | 33.26 | 32.06 | 31.22 | 30.63 | 30.18 | 29.85 | 4.19 |
| 4.20 | 35.22 | 33.39 | 32.18 | 31.35 | 30.75 | 30.30 | 29.96 | 4.20 |
| 4.21 | 35.36 | 33.52 | 32.30 | 31.47 | 30.87 | 30.41 | 30.07 | 4.21 |
| 4.22 | 35.49 | 33.65 | 32.43 | 31.59 | 30.99 | 30.52 | 30.18 | 4.22 |
| 4.23 | 35.63 | 33.78 | 32.55 | 31.71 | 31.11 | 30.63 | 30.29 | 4.23 |
| 4.24 | 35.76 | 33.91 | 32.67 | 31.83 | 31.23 | 30.74 | 30.41 | 4.24 |
| 4.25 | 35.90 | 34.04 | 32.79 | 31.95 | 31.35 | 30.85 | 30.52 | 4.25 |
| 4.26 | 36.04 | 34.17 | 32.92 | 32.07 | 31.47 | 30.92 | 30.64 | 4.26 |
| 4.27 | 36.18 | 34.30 | 33.04 | 32.19 | 31.58 | 31.08 | 30.76 | 4.27 |
| 4.28 | 36.31 | 34.43 | 33.17 | 32.31 | 31.70 | 31.20 | 30.88 | 4.28 |
| 4.29 | 36.45 | 34.56 | 33.30 | 32.43 | 31.81 | 31.31 | 30.99 | 4.29 |
| 4.30 | 36.59 | 34.68 | 33.43 | 32.55 | 31.93 | 31.42 | 31.10 | 4.30 |
| 4.31 | 36.73 | 34.81 | 33.55 | 32.67 | 32.04 | 31.54 | 31.23 | 4.31 |
| 4.32 | 36.87 | 34.95 | 33.68 | 32.79 | 32.16 | 31.65 | 31.33 | 4.32 |
| 4.33 | 37.01 | 35.08 | 33.81 | 32.91 | 32.27 | 31.77 | 31.44 | 4.33 |
| 4.34 | 37.15 | 35.22 | 33.93 | 33.03 | 32.38 | 31.89 | 31.56 | 4.34 |
| 4.35 | 37.28 | 35.35 | 34.06 | 33.15 | 32.50 | 32.01 | 31.67 | 4.35 |
| 4.36 | 37.43 | 35.49 | 34.19 | 33.28 | 32.63 | 32.13 | 31.78 | 4.36 |
| 4.37 | 37.57 | 35.62 | 34.31 | 33.40 | 32.75 | 32.25 | 31.89 | 4.37 |
| 4.38 | 37.71 | 35.75 | 34.44 | 33.53 | 32.88 | 32.37 | 32.00 | 4.38 |
| 4.39 | 37.85 | 35.88 | 34.57 | 33.65 | 33.00 | 32.49 | 32.12 | 4.39 |
| 4.40 | 37.99 | 36.01 | 34.70 | 33.78 | 33.12 | 32.62 | 32.24 | 4.40 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet | $p=9$ Ft. $Q$ Cu. Ft. per Sec. | $p=10$ Ft. $Q$ Cu. Ft. per Sec. | $p=12$ Ft. $Q$ Cu. Ft. per Sec. | $p=16$ Ft. $Q$ Cu. Ft. per Sec. | $p=20$ Ft. $Q$ Cu. Ft. per Sec. | $p=25$ Ft. $Q$ Cu. Ft. per Sec. | $p=30$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 4.01 | 27.61 | 27.42 | 27.15 | 26.82 | 26.65 | 26.52 | 26.44 | 4.01 |
| 4.02 | 27.71 | 27.52 | 27.25 | 26.92 | 26.75 | 26.62 | 26.54 | 4.02 |
| 4.03 | 27.82 | 27.63 | 27.36 | 27.02 | 26.85 | 26.72 | 26.64 | 4.03 |
| 4.04 | 27.92 | 27.73 | 27.46 | 27.12 | 26.95 | 26.82 | 26.73 | 4.04 |
| 4.05 | 28.03 | 27.84 | 27.56 | 27.22 | 27.04 | 26.92 | 26.83 | 4.05 |
| 4.06 | 28.14 | 27.95 | 27.67 | 27.33 | 27.14 | 27.02 | 26.93 | 4.06 |
| 4.07 | 28.25 | 28.05 | 27.77 | 27.43 | 27.24 | 27.12 | 27.03 | 4.07 |
| 4.08 | 28.36 | 28.16 | 27.88 | 27.53 | 27.35 | 27.22 | 27.13 | 4.08 |
| 4.09 | 28.46 | 28.26 | 27.99 | 27.63 | 27.45 | 27.32 | 27.23 | 4.09 |
| 4.10 | 28.57 | 28.36 | 28.10 | 27.74 | 27.55 | 27.42 | 27.33 | 4.10 |
| 4.11 | 28.68 | 28.47 | 28.20 | 27.85 | 27.65 | 27.52 | 27.44 | 4.11 |
| 4.12 | 28.79 | 28.58 | 28.31 | 27.96 | 27.75 | 27.63 | 27.54 | 4.12 |
| 4.13 | 28.90 | 28.69 | 28.41 | 28.06 | 27.86 | 27.73 | 27.64 | 4.13 |
| 4.14 | 29.01 | 28.80 | 28.52 | 28.17 | 27.96 | 27.83 | 27.74 | 4.14 |
| 4.15 | 29.12 | 28.92 | 28.63 | 28.27 | 28.07 | 27.93 | 27.84 | 4.15 |
| 4.16 | 29.24 | 29.03 | 28.74 | 28.37 | 28.17 | 28.04 | 27.94 | 4.16 |
| 4.17 | 29.35 | 29.14 | 28.84 | 28.48 | 28.27 | 28.14 | 28.05 | 4.17 |
| 4.18 | 29.46 | 29.25 | 28.95 | 28.58 | 28.37 | 28.24 | 28.15 | 4.18 |
| 4.19 | 29.57 | 29.36 | 29.05 | 28.68 | 28.48 | 28.34 | 28.25 | 4.19 |
| 4.20 | 29.69 | 29.48 | 29.17 | 28.79 | 28.59 | 28.45 | 28.36 | 4.20 |
| 4.21 | 29.80 | 29.59 | 29.28 | 28.89 | 28.69 | 28.55 | 28.46 | 4.21 |
| 4.22 | 29.91 | 29.70 | 29.38 | 29.00 | 28.79 | 28.65 | 28.56 | 4.22 |
| 4.23 | 30.02 | 29.81 | 29.49 | 29.11 | 28.89 | 28.75 | 28.66 | 4.23 |
| 4.24 | 30.13 | 29.92 | 29.59 | 29.22 | 28.99 | 28.85 | 28.76 | 4.24 |
| 4.25 | 30.24 | 30.03 | 29.70 | 29.33 | 29.10 | 28.96 | 28.86 | 4.25 |
| 4.26 | 30.35 | 30.14 | 29.81 | 29.43 | 29.20 | 29.07 | 28.96 | 4.26 |
| 4.27 | 30.46 | 30.25 | 29.92 | 29.53 | 29.31 | 25.17 | 29.06 | 4.27 |
| 4.28 | 30.57 | 30.36 | 30.02 | 29.64 | 29.42 | 29.27 | 29.16 | 4.28 |
| 4.29 | 30.68 | 30.47 | 30.13 | 29.74 | 29.52 | 29.37 | 29.27 | 4.29 |
| 4.30 | 30.79 | 30.58 | 30.24 | 29.85 | 29.62 | 29.48 | 29.37 | 4.30 |
| 4.31 | 30.91 | 30.69 | 30.35 | 29.95 | 29.73 | 29.58 | 29.48 | 4.31 |
| 4.32 | 31.03 | 30.80 | 30.46 | 30.06 | 29.83 | 29.68 | 29.58 | 4.32 |
| 4.33 | 31.14 | 30.91 | 30.56 | 30.17 | 29.93 | 29.78 | 29.69 | 4.33 |
| 4.34 | 31.25 | 31.02 | 30.67 | 30.27 | 30.03 | 29.89 | 29.79 | 4.34 |
| 4.35 | 31.36 | 31.14 | 30.78 | 30.37 | 30.13 | 29.99 | 29.89 | 4.35 |
| 4.36 | 31.48 | 31.26 | 30.89 | 30.48 | 30.24 | 30.10 | 30.00 | 4.36 |
| 4.37 | 31.59 | 31.37 | 31.00 | 30.59 | 30.34 | 30.20 | 30.10 | 4.37 |
| 4.38 | 31.70 | 31.48 | 31.11 | 30.70 | 30.45 | 30.30 | 30.21 | 4.38 |
| 4.39 | 31.82 | 31 59 | 31.23 | 30.81 | 30.55 | 30.41 | 30.31 | 4.39 |
| 4.40 | 31.94 | 31.70 | 31.34 | 30.92 | 30.66 | 30.52 | 30.42 | 4.40 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet.
Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet |
|---|---|---|---|---|---|---|---|---|
| 4.41 | 38.13 | 36.15 | 34.83 | 33.90 | 33.24 | 32.73 | 32.35 | 4.41 |
| 4.42 | 38.27 | 36.28 | 34.96 | 34.02 | 33.36 | 32.84 | 32.46 | 4.42 |
| 4.43 | 38.41 | 36.41 | 35.08 | 34.14 | 33.48 | 32.96 | 32.57 | 4.43 |
| 4.44 | 38.55 | 36.54 | 35.21 | 34.26 | 33.60 | 33.08 | 32.68 | 4.44 |
| 4.45 | 38.69 | 36.68 | 35.34 | 34.39 | 33.72 | 33.20 | 32.80 | 4.45 |
| 4.46 | 38.83 | 36.81 | 35.47 | 34.52 | 33.84 | 33.32 | 32.92 | 4.46 |
| 4.47 | 38.98 | 36.94 | 35.60 | 34.64 | 33.96 | 33.43 | 33.04 | 4.47 |
| 4.48 | 39.12 | 37.08 | 35.72 | 34.76 | 34.08 | 33.54 | 33.16 | 4.48 |
| 4.49 | 39.26 | 37.22 | 35.85 | 34.88 | 34.21 | 33.66 | 33.27 | 4.49 |
| 4.50 | 39.40 | 37.36 | 35.98 | 35.01 | 34.33 | 33.77 | 33.39 | 4.50 |
| 4.51 | 39.54 | 37.49 | 36.11 | 35.14 | 34.46 | 33.89 | 33.50 | 4.51 |
| 4.52 | 39.69 | 37.62 | 36.25 | 35.26 | 34.58 | 34.01 | 33.62 | 4.52 |
| 4.53 | 39.84 | 37.76 | 36.38 | 35.39 | 34.70 | 34.14 | 33.74 | 4.53 |
| 4.54 | 39.98 | 37.90 | 36.51 | 35.51 | 34.82 | 34.26 | 33.86 | 4.54 |
| 4.55 | 40.12 | 38.03 | 36.64 | 35.64 | 34.94 | 34.38 | 33.98 | 4.55 |
| 4.56 | 40.26 | 38.17 | 36.77 | 35.78 | 35.06 | 34.51 | 34.10 | 4.56 |
| 4.57 | 40.40 | 38.31 | 36.90 | 35.91 | 35.19 | 34.63 | 34.22 | 4.57 |
| 4.58 | 40.55 | 38.44 | 37.03 | 36.04 | 35.31 | 34.75 | 34.34 | 4.58 |
| 4.59 | 40.70 | 38.57 | 37.16 | 36.17 | 35.43 | 34.88 | 34.46 | 4.59 |
| 4.60 | 40.83 | 38.71 | 37.29 | 36.29 | 35.56 | 35.01 | 34.58 | 4.60 |
| 4.61 | 40.98 | 38.85 | 37.43 | 36.42 | 35.69 | 35.13 | 34.69 | 4.61 |
| 4.62 | 41.13 | 38.99 | 37.56 | 36.55 | 35.82 | 35.25 | 34.81 | 4.62 |
| 4.63 | 41.27 | 39.13 | 37.69 | 36.68 | 35.95 | 35.37 | 34.92 | 4.63 |
| 4.64 | 41.41 | 39.27 | 37.82 | 36.80 | 36.07 | 35.49 | 35.04 | 4.64 |
| 4.65 | 41.55 | 39.41 | 37.96 | 36.93 | 36.19 | 35.61 | 35.16 | 4.65 |
| 4.66 | 41.71 | 39.55 | 38.09 | 37.06 | 36.32 | 35.73 | 35.28 | 4.66 |
| 4.67 | 41.85 | 39.68 | 38.22 | 37.19 | 36.44 | 35.85 | 35.39 | 4.67 |
| 4.68 | 42.00 | 39.82 | 38.36 | 37.32 | 36.57 | 35.97 | 35.51 | 4.68 |
| 4.69 | 42.14 | 39.95 | 38.49 | 37.45 | 36.69 | 36.09 | 35.63 | 4.69 |
| 4.70 | 42.29 | 40.08 | 38.62 | 37.58 | 36.82 | 36.21 | 35.75 | 4.70 |
| 4.71 | 42.44 | 40.22 | 38.76 | 37.71 | 36.95 | 36.34 | 35.89 | 4.71 |
| 4.72 | 42.58 | 40.36 | 38.89 | 37.84 | 37.07 | 36.46 | 36.01 | 4.72 |
| 4.73 | 42.72 | 40.50 | 39.03 | 37.96 | 37.20 | 36.58 | 36.13 | 4.73 |
| 4.74 | 42.87 | 40.64 | 39.16 | 38.09 | 37.32 | 36.71 | 36.25 | 4.74 |
| 4.75 | 43.01 | 40.78 | 39.29 | 38.22 | 37.45 | 36.83 | 36.38 | 4.75 |
| 4.76 | 43.16 | 40.92 | 39.43 | 38.35 | 37.57 | 36.96 | 36.51 | 4.76 |
| 4.77 | 43.30 | 41.06 | 39.56 | 38.48 | 37.69 | 37.08 | 36.63 | 4.77 |
| 4.78 | 43.45 | 41.20 | 39.70 | 38.61 | 37.81 | 37.21 | 36.75 | 4.78 |
| 4.79 | 43.60 | 41.34 | 39.83 | 38.74 | 37.93 | 37.33 | 36.87 | 4.79 |
| 4.80 | 43.75 | 41.49 | 39.96 | 38.87 | 38.07 | 37.46 | 37.00 | 4.80 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. $Q$ Cu. Ft. per Sec. | $p=10$ Ft. $Q$ Cu. Ft. per Sec. | $p=12$ Ft. $Q$ Cu. Ft. per Sec. | $p=16$ Ft. $Q$ Cu. Ft. per Sec. | $p=20$ Ft. $Q$ Cu. Ft. per Sec. | $p=25$ Ft. $Q$ Cu. Ft. per Sec. | $p=30$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 4.41 | 32.05 | 31.81 | 31.44 | 31.02 | 30.77 | 30.62 | 30.52 | 4.41 |
| 4.42 | 32.17 | 31.90 | 31.55 | 31.13 | 30.87 | 30.72 | 30.63 | 4.42 |
| 4.43 | 32.28 | 32.03 | 31.66 | 31.23 | 30.98 | 30.83 | 30.73 | 4.43 |
| 4.44 | 32.39 | 32.14 | 31.77 | 31.34 | 31.09 | 30.93 | 30.84 | 4.44 |
| 4.45 | 32.50 | 32.25 | 31.88 | 31.44 | 31.19 | 31.04 | 30.94 | 4.45 |
| 4.46 | 32.62 | 32.37 | 31.99 | 31.55 | 31.30 | 31.15 | 31.05 | 4.46 |
| 4.47 | 32.74 | 32.49 | 32.11 | 31.65 | 31.41 | 31.26 | 31.15 | 4.47 |
| 4.48 | 32.85 | 32.60 | 32.22 | 31.76 | 31.52 | 31.37 | 31.25 | 4.48 |
| 4.49 | 32.96 | 32.71 | 32.33 | 31.87 | 31.63 | 31.47 | 31.36 | 4.49 |
| 4.50 | 33.08 | 32.83 | 32.44 | 31.98 | 31.74 | 31.58 | 31.47 | 4.50 |
| 4.51 | 33.19 | 32.94 | 32.55 | 32.10 | 31.85 | 31.69 | 31.58 | 4.51 |
| 4.52 | 33.31 | 33.05 | 32.66 | 32.22 | 31.96 | 31.79 | 31.68 | 4.52 |
| 4.53 | 33.42 | 33.16 | 32.77 | 32.33 | 32.07 | 31.89 | 31.79 | 4.53 |
| 4.54 | 33.53 | 33.27 | 32.89 | 32.44 | 32.18 | 32.00 | 31.89 | 4.54 |
| 4.55 | 33.65 | 33.38 | 33.00 | 32.55 | 32.29 | 32.10 | 32.00 | 4.55 |
| 4.56 | 33.77 | 33.50 | 33.12 | 32.66 | 32.40 | 32.22 | 32.10 | 4.56 |
| 4.57 | 33.89 | 33.62 | 33.24 | 32.77 | 32.51 | 32.33 | 32.21 | 4.57 |
| 4.58 | 34.01 | 33.74 | 33.35 | 32.88 | 32.62 | 32.44 | 32.31 | 4.58 |
| 4.59 | 34.13 | 33.86 | 33.46 | 32.99 | 32.73 | 32.55 | 32.42 | 4.59 |
| 4.60 | 34.25 | 33.98 | 33.58 | 33.10 | 32.84 | 32.65 | 32.53 | 4.60 |
| 4.61 | 34.37 | 34.09 | 33.69 | 33.21 | 32.94 | 32.76 | 32.64 | 4.61 |
| 4.62 | 34.48 | 34.21 | 33.80 | 33.32 | 33.04 | 32.86 | 32.75 | 4.62 |
| 4.63 | 34.59 | 34.32 | 33.91 | 33.43 | 33.15 | 32.97 | 32.86 | 4.63 |
| 4.64 | 34.70 | 34.43 | 34.02 | 33.54 | 33.26 | 33.08 | 32.96 | 4.64 |
| 4.65 | 34.82 | 34.55 | 34.14 | 33.65 | 33.37 | 33.18 | 33.07 | 4.65 |
| 4.66 | 34.94 | 34.67 | 34.26 | 33.76 | 33.48 | 33.29 | 33.18 | 4.66 |
| 4.67 | 35.06 | 34.79 | 34.37 | 33.88 | 33.59 | 33.40 | 33.28 | 4.67 |
| 4.68 | 35.18 | 34.91 | 34.48 | 33.99 | 33.70 | 33.50 | 33.39 | 4.68 |
| 4.69 | 35.29 | 35.02 | 34.59 | 34.10 | 33.82 | 33.61 | 33.50 | 4.69 |
| 4.70 | 35.40 | 35.13 | 34.71 | 34.22 | 33.93 | 33.72 | 33.61 | 4.70 |
| 4.71 | 35.52 | 35.25 | 34.83 | 34.33 | 34.04 | 33.83 | 33.72 | 4.71 |
| 4.72 | 35.64 | 35.36 | 34.94 | 34.45 | 34.15 | 33.94 | 33.82 | 4.72 |
| 4.73 | 35.76 | 35.48 | 35.06 | 34.56 | 34.26 | 34.05 | 33.93 | 4.73 |
| 4.74 | 35.88 | 35.60 | 35.17 | 34.67 | 34.37 | 34.16 | 34.04 | 4.74 |
| 4.75 | 36.00 | 35.72 | 35.28 | 34.78 | 34.48 | 34.28 | 34.15 | 4.75 |
| 4.76 | 36.13 | 35.84 | 35.40 | 34.90 | 34.59 | 34.39 | 34.26 | 4.76 |
| 4.77 | 36.25 | 35.96 | 35.52 | 35.01 | 34.70 | 34.50 | 34.37 | 4.77 |
| 4.78 | 36.37 | 36.08 | 35.64 | 35.12 | 34.82 | 34.61 | 34.48 | 4.78 |
| 4.79 | 36.48 | 36.20 | 35.76 | 35.24 | 34.93 | 34.72 | 34.59 | 4.79 |
| 4.80 | 36.62 | 36.33 | 35.88 | 35.35 | 35.05 | 34.83 | 34.70 | 4.80 |

DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 4.81 | 43.90 | 41.32 | 40.10 | 39.00 | 38.20 | 37.58 | 37.12 | 4.81 |
| 4.82 | 44.05 | 41.76 | 40.23 | 39.12 | 38.32 | 37.70 | 37.24 | 4.82 |
| 4.83 | 44.20 | 41.90 | 40.36 | 39.25 | 38.45 | 37.82 | 37.36 | 4.83 |
| 4.84 | 44.35 | 42.04 | 40.49 | 39.38 | 38.58 | 37.94 | 37.48 | 4.84 |
| 4.85 | 44.50 | 42.18 | 40.63 | 39.51 | 38.70 | 38.07 | 37.60 | 4.85 |
| 4.86 | 44.64 | 42.32 | 40.77 | 39.64 | 38.83 | 38.20 | 37.72 | 4.86 |
| 4.87 | 44.78 | 42.46 | 40.90 | 39.77 | 38.96 | 38.32 | 37.84 | 4.87 |
| 4.88 | 44.93 | 42.60 | 41.04 | 39.90 | 39.09 | 38.44 | 37.96 | 4.88 |
| 4.89 | 45.07 | 42.74 | 41.17 | 40.03 | 39.23 | 38.57 | 38.08 | 4.89 |
| 4.90 | 45.22 | 42.88 | 41.30 | 40.16 | 39.35 | 38.69 | 38.20 | 4.90 |
| 4.91 | 45.37 | 43.02 | 41.44 | 40.30 | 39.48 | 38.82 | 38.32 | 4.91 |
| 4.92 | 45.51 | 43.16 | 41.57 | 40.43 | 39.61 | 38.94 | 38.44 | 4.92 |
| 4.93 | 45.65 | 43.31 | 41.70 | 40.56 | 39.74 | 39.06 | 38.56 | 4.93 |
| 4.94 | 45.80 | 43.45 | 41.84 | 40.69 | 39.87 | 39.19 | 38.68 | 4.94 |
| 4.95 | 45.95 | 43.59 | 41.98 | 40.82 | 39.99 | 39.32 | 38.81 | 4.95 |
| 4.96 | 46.10 | 43.73 | 42.12 | 40.96 | 40.12 | 39.44 | 38.93 | 4.96 |
| 4.97 | 46.25 | 43.87 | 42.26 | 41.09 | 40.25 | 39.57 | 39.06 | 4.97 |
| 4.98 | 46.40 | 44.02 | 42.39 | 41.22 | 40.39 | 39.70 | 39.19 | 4.98 |
| 4.99 | 46.55 | 44.16 | 42.53 | 41.35 | 40.49 | 39.83 | 39.32 | 4.99 |
| 5.00 | 46.71 | 44.31 | 42.67 | 41.49 | 40.62 | 39.96 | 39.44 | 5.00 |
| 5.01 | 46.86 | 44.46 | 42.80 | 41.62 | 40.75 | 40.08 | 39.56 | 5.01 |
| 5.02 | 47.01 | 44.60 | 42.94 | 41.75 | 40.88 | 40.20 | 39.69 | 5.02 |
| 5.03 | 47.16 | 44.75 | 43.08 | 41.88 | 41.00 | 40.33 | 39.82 | 5.03 |
| 5.04 | 47.32 | 44.89 | 43.22 | 42.02 | 41.12 | 40.45 | 39.94 | 5.04 |
| 5.05 | 47.48 | 45.03 | 43.36 | 42.15 | 41.25 | 40.58 | 40.07 | 5.05 |
| 5.06 | 47.63 | 45.18 | 43.50 | 42.29 | 41.38 | 40.72 | 40.20 | 5.06 |
| 5.07 | 47.79 | 45.33 | 43.64 | 42.43 | 41.51 | 40.85 | 40.33 | 5.07 |
| 5.08 | 47.94 | 45.48 | 43.78 | 42.57 | 41.64 | 40.98 | 40.45 | 5.08 |
| 5.09 | 48.09 | 45.63 | 43.92 | 42.70 | 41.77 | 41.11 | 40.58 | 5.09 |
| 5.10 | 48.25 | 45.77 | 44.06 | 42.84 | 41.90 | 41.24 | 40.70 | 5.10 |
| 5.11 | 48.40 | 45.92 | 44.20 | 42.98 | 42.03 | 41.37 | 40.82 | 5.11 |
| 5.12 | 48.56 | 46.07 | 44.35 | 43.12 | 42.17 | 41.50 | 40.95 | 5.12 |
| 5.13 | 48.71 | 46.22 | 44.49 | 43.25 | 42.31 | 41.63 | 41.07 | 5.13 |
| 5.14 | 48.86 | 46.37 | 44.63 | 43.39 | 42.45 | 41.76 | 41.20 | 5.14 |
| 5.15 | 49.02 | 46.52 | 44.77 | 43.53 | 42.59 | 41.89 | 41.33 | 5.15 |
| 5.16 | 49.18 | 46.67 | 44.92 | 43.67 | 42.73 | 42.03 | 41.46 | 5.16 |
| 5.17 | 49.34 | 46.82 | 45.06 | 43.81 | 42.87 | 42.17 | 41.60 | 5.17 |
| 5.18 | 49.49 | 46.97 | 45.20 | 43.95 | 43.01 | 42.30 | 41.74 | 5.18 |
| 5.19 | 49.65 | 47.12 | 45.35 | 44.09 | 43.15 | 42.43 | 41.88 | 5.19 |
| 5.20 | 49.81 | 47.27 | 45.50 | 44.23 | 43.29 | 42.57 | 42.02 | 5.20 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. $Q$ Cu. Ft. per Sec. | $p=10$ Ft. $Q$ Cu. Ft. per Sec. | $p=12$ Ft. $Q$ Cu. Ft. per Sec. | $p=16$ Ft. $Q$ Cu. Ft. per Sec. | $p=20$ Ft. $Q$ Cu. Ft. per Sec. | $p=25$ Ft. $Q$ Cu. Ft. per Sec. | $p=30$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 4.81 | 36.73 | 36.44 | 35.99 | 35.46 | 35.15 | 34.94 | 34.80 | 4.81 |
| 4.82 | 36.85 | 36.56 | 36.10 | 35.57 | 35.26 | 35.05 | 34.91 | 4.82 |
| 4.83 | 36.97 | 36.67 | 36.22 | 35.68 | 35.37 | 35.16 | 35.02 | 4.83 |
| 4.84 | 37.08 | 36.79 | 36.34 | 35.79 | 35.48 | 35.27 | 35.12 | 4.84 |
| 4.85 | 37.19 | 36.91 | 36.45 | 35.90 | 35.59 | 35.38 | 35.23 | 4.85 |
| 4.86 | 37.31 | 37.02 | 36.57 | 36.02 | 35.70 | 35.49 | 35.34 | 4.86 |
| 4.87 | 37.43 | 37.14 | 36.68 | 36.13 | 35.81 | 35.60 | 35.45 | 4.87 |
| 4.88 | 37.55 | 37.26 | 36.79 | 36.24 | 35.93 | 35.71 | 35.56 | 4.88 |
| 4.89 | 37.67 | 37.37 | 36.91 | 36.36 | 36.04 | 35.82 | 35.66 | 4.89 |
| 4.90 | 37.79 | 37.49 | 37.03 | 36.47 | 36.15 | 35.93 | 35.77 | 4.90 |
| 4.91 | 37.91 | 37.61 | 37.15 | 36.58 | 36.27 | 36.04 | 35.88 | 4.91 |
| 4.92 | 38.03 | 37.73 | 37.27 | 36.70 | 36.38 | 36.15 | 35.99 | 4.92 |
| 4.93 | 38.15 | 37.85 | 37.39 | 36.81 | 36.50 | 36.26 | 36.10 | 4.93 |
| 4.94 | 38.28 | 37.97 | 37.51 | 36.92 | 36.61 | 36.37 | 36.21 | 4.94 |
| 4.95 | 38.40 | 38.09 | 37.63 | 37.03 | 36.72 | 36.48 | 36.32 | 4.95 |
| 4.96 | 38.53 | 38.22 | 37.75 | 37.15 | 36.84 | 36.59 | 36.43 | 4.96 |
| 4.97 | 38.65 | 38.34 | 37.87 | 37.27 | 36.95 | 36.70 | 36.54 | 4.97 |
| 4.98 | 38.78 | 38.46 | 37.98 | 37.38 | 37.06 | 36.81 | 36.65 | 4.98 |
| 4.99 | 38.90 | 38.58 | 38.10 | 37.50 | 37.17 | 36.92 | 36.76 | 4.99 |
| 5.00 | 39.03 | 38.70 | 38.21 | 37.61 | 37.28 | 37.03 | 36.88 | 5.00 |
| 5.01 | 39.15 | 38.82 | 38.33 | 37.73 | 37.40 | 37.14 | 36.99 | 5.01 |
| 5.02 | 39.27 | 38.94 | 38.44 | 37.84 | 37.52 | 37.26 | 37.10 | 5.02 |
| 5.03 | 39.40 | 39.07 | 38.56 | 37.96 | 37.63 | 37.38 | 37.21 | 5.03 |
| 5.04 | 39.52 | 39.19 | 38.68 | 38.08 | 37.75 | 37.49 | 37.32 | 5.04 |
| 5.05 | 39.66 | 39.32 | 38.80 | 38.19 | 37.87 | 37.60 | 37.44 | 5.05 |
| 5.06 | 39.79 | 39.45 | 38.92 | 38.31 | 37.98 | 37.72 | 37.55 | 5.06 |
| 5.07 | 39.92 | 39.57 | 39.04 | 38.43 | 38.10 | 37.84 | 37.66 | 5.07 |
| 5.08 | 40.04 | 39.70 | 39.16 | 38.55 | 38.22 | 37.95 | 37.77 | 5.08 |
| 5.09 | 40.16 | 39.83 | 39.28 | 38.66 | 38.33 | 38.06 | 37.89 | 5.09 |
| 5.10 | 40.28 | 39.95 | 39.41 | 38.78 | 38.44 | 38.17 | 38.00 | 5.10 |
| 5.11 | 40.41 | 40.08 | 39.53 | 38.90 | 38.56 | 38.29 | 38.12 | 5.11 |
| 5.12 | 40.54 | 40.20 | 39.66 | 39.02 | 38.67 | 38.41 | 38.23 | 5.12 |
| 5.13 | 40.66 | 40.33 | 39.78 | 39.14 | 38.79 | 38.52 | 38.34 | 5.13 |
| 5.14 | 40.78 | 40.46 | 39.90 | 39.26 | 38.90 | 38.63 | 38.46 | 5.14 |
| 5.15 | 40.91 | 40.58 | 40.02 | 39.38 | 39.02 | 38.75 | 38.57 | 5.15 |
| 5.16 | 41.04 | 40.71 | 40.15 | 39.50 | 39.13 | 38.87 | 38.69 | 5.16 |
| 5.17 | 41.17 | 40.83 | 40.27 | 39.62 | 39.25 | 38.98 | 38.81 | 5.17 |
| 5.18 | 41.30 | 40.95 | 40.40 | 39.74 | 39.37 | 39.10 | 38.93 | 5.18 |
| 5.19 | 41.43 | 41.08 | 40.52 | 39.86 | 39.49 | 39.22 | 39.05 | 5.19 |
| 5.20 | 41.56 | 41.20 | 40.65 | 39.99 | 39.61 | 39.33 | 39.17 | 5.20 |

# DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

## COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet.
Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 5.21 | 49.96 | 47.42 | 45.64 | 44.36 | 43.42 | 42.70 | 42.10 | 5.21 |
| 5.22 | 50.11 | 47.56 | 45.78 | 44.50 | 43.55 | 42.83 | 42.23 | 5.22 |
| 5.23 | 50.27 | 47.71 | 45.92 | 44.64 | 43.69 | 42.96 | 42.36 | 5.23 |
| 5.24 | 50.42 | 47.86 | 46.06 | 44.78 | 43.82 | 43.09 | 42.49 | 5.24 |
| 5.25 | 50.58 | 48.01 | 46.21 | 44.92 | 43.95 | 43.22 | 42.62 | 5.25 |
| 5.26 | 50.74 | 48.16 | 46.35 | 45.06 | 44.09 | 43.35 | 42.75 | 5.26 |
| 5.27 | 50.90 | 48.31 | 46.49 | 45.20 | 44.22 | 43.48 | 42.88 | 5.27 |
| 5.28 | 51.05 | 48.45 | 46.63 | 45.34 | 44.36 | 43.61 | 43.01 | 5.28 |
| 5.29 | 51.20 | 48.60 | 46.78 | 45.48 | 44.49 | 43.74 | 43.14 | 5.29 |
| 5.30 | 51.36 | 48.75 | 46.92 | 45.62 | 44.63 | 43.88 | 43.28 | 5.30 |
| 5.31 | 51.52 | 48.90 | 47.07 | 45.76 | 44.77 | 44.01 | 43.41 | 5.31 |
| 5.32 | 51.67 | 49.05 | 47.22 | 45.90 | 44.90 | 44.14 | 43.54 | 5.32 |
| 5.33 | 51.82 | 49.20 | 47.37 | 46.04 | 45.03 | 44.28 | 43.67 | 5.33 |
| 5.34 | 51.98 | 49.35 | 47.51 | 46.18 | 45.17 | 44.42 | 43.80 | 5.34 |
| 5.35 | 52.15 | 49.50 | 47.67 | 46.32 | 45.31 | 44.55 | 43.93 | 5.35 |
| 5.36 | 52.30 | 49.65 | 47.82 | 46.46 | 45.44 | 44.69 | 44.06 | 5.36 |
| 5.37 | 52.46 | 49.80 | 47.97 | 46.60 | 45.58 | 44.82 | 44.19 | 5.37 |
| 5.38 | 52.62 | 49.95 | 48.11 | 46.74 | 45.72 | 44.95 | 44.33 | 5.38 |
| 5.39 | 52.78 | 50.09 | 48.24 | 46.88 | 45.86 | 45.08 | 44.46 | 5.39 |
| 5.40 | 52.94 | 50.23 | 48.38 | 47.02 | 46.00 | 45.22 | 44.60 | 5.40 |
| 5.41 | 53.10 | 50.38 | 48.53 | 47.15 | 46.13 | 45.34 | 44.73 | 5.41 |
| 5.42 | 53.25 | 50.53 | 48.68 | 47.28 | 46.26 | 45.49 | 44.86 | 5.42 |
| 5.43 | 53.42 | 50.68 | 48.83 | 47.42 | 46.39 | 45.62 | 44.99 | 5.43 |
| 5.44 | 53.57 | 50.83 | 48.98 | 47.56 | 46.53 | 45.76 | 45.12 | 5.44 |
| 5.45 | 53.72 | 50.98 | 49.13 | 47.71 | 46.67 | 45.89 | 45.26 | 5.45 |
| 5.46 | 53.88 | 51.13 | 49.28 | 47.86 | 46.81 | 46.03 | 45.40 | 5.46 |
| 5.47 | 54.04 | 51.28 | 49.43 | 48.00 | 46.94 | 46.17 | 45.53 | 5.47 |
| 5.48 | 54.20 | 51.43 | 49.58 | 48.14 | 47.08 | 46.31 | 45.67 | 5.48 |
| 5.49 | 54.36 | 51.59 | 49.73 | 48.28 | 47.22 | 46.44 | 45.80 | 5.49 |
| 5.50 | 54.51 | 51.74 | 49.88 | 48.42 | 47.36 | 46.57 | 45.93 | 5.50 |
| 5.51 | 54.68 | 51.90 | 50.03 | 48.56 | 47.50 | 46.71 | 46.08 | 5.51 |
| 5.52 | 54.84 | 52.05 | 50.18 | 48.71 | 47.64 | 46.85 | 46.20 | 5.52 |
| 5.53 | 55.00 | 52.21 | 50.33 | 48.85 | 47.79 | 46.99 | 46.35 | 5.53 |
| 5.54 | 55.16 | 52.37 | 50.48 | 48.99 | 47.94 | 47.12 | 46.48 | 5.54 |
| 5.55 | 55.33 | 52.53 | 50.62 | 49.13 | 48.08 | 47.26 | 46.61 | 5.55 |
| 5.56 | 55.49 | 52.69 | 50.76 | 49.28 | 48.22 | 47.40 | 46.75 | 5.56 |
| 5.57 | 55.65 | 52.85 | 50.90 | 49.45 | 48.36 | 47.53 | 46.89 | 5.57 |
| 5.58 | 55.82 | 53.01 | 51.04 | 49.58 | 48.50 | 47.67 | 47.02 | 5.58 |
| 5.59 | 56.00 | 53.17 | 51.19 | 49.73 | 48.64 | 47.80 | 47.15 | 5.59 |
| 5.60 | 56.15 | 53.33 | 51.34 | 49.88 | 48.79 | 47.94 | 47.28 | 5.60 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. $Q$ Cu. Ft. per Sec. | $p=10$ Ft. $Q$ Cu. Ft. per Sec. | $p=12$ Ft. $Q$ Cu. Ft. per Sec. | $p=16$ Ft. $Q$ Cu. Ft. per Sec. | $p=20$ Ft. $Q$ Cu. Ft. per Sec. | $p=25$ Ft. $Q$ Cu. Ft. per Sec. | $p=30$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 5.21 | 41.68 | 41.33 | 40.77 | 40.09 | 39.72 | 39.45 | 39.28 | 5.21 |
| 5.22 | 41.81 | 41.45 | 40.89 | 40.21 | 39.84 | 39.56 | 39.39 | 5.22 |
| 5.23 | 41.93 | 41.58 | 41.01 | 40.32 | 39.95 | 39.68 | 39.51 | 5.23 |
| 5.24 | 42.05 | 41.70 | 41.13 | 40.44 | 40.06 | 39.80 | 39.62 | 5.24 |
| 5.25 | 42.18 | 41.83 | 41.25 | 40.56 | 40.17 | 39.92 | 39.74 | 5.25 |
| 5.26 | 42.30 | 41.96 | 41.38 | 40.68 | 40.29 | 40.03 | 39.86 | 5.26 |
| 5.27 | 42.43 | 42.08 | 41.51 | 40.80 | 40.40 | 40.15 | 39.97 | 5.27 |
| 5.28 | 42.56 | 42.20 | 41.63 | 40.91 | 40.52 | 40.26 | 40.08 | 5.28 |
| 5.29 | 42.69 | 42.33 | 41.75 | 41.03 | 40.64 | 40.38 | 40.19 | 5.29 |
| 5.30 | 42.81 | 42.45 | 41.87 | 41.16 | 40.76 | 40.49 | 40.30 | 5.30 |
| 5.31 | 42.94 | 42.58 | 41.99 | 41.28 | 40.88 | 40.61 | 40.42 | 5.31 |
| 5.32 | 43.07 | 42.71 | 42.12 | 41.41 | 41.00 | 40.73 | 40.54 | 5.32 |
| 5.33 | 43.20 | 42.83 | 42.25 | 41.53 | 41.12 | 40.85 | 40.65 | 5.33 |
| 5.34 | 43.33 | 42.95 | 42.37 | 41.65 | 41.24 | 40.96 | 40.76 | 5.34 |
| 5.35 | 43.46 | 43.08 | 42.49 | 41.77 | 41.36 | 41.08 | 40.88 | 5.35 |
| 5.36 | 43.59 | 43.21 | 42.62 | 41.89 | 41.48 | 41.20 | 41.00 | 5.36 |
| 5.37 | 43.72 | 43.33 | 42.74 | 42.02 | 41.60 | 41.32 | 41.12 | 5.37 |
| 5.38 | 43.85 | 43.46 | 42.87 | 42.14 | 41.72 | 41.44 | 41.24 | 5.38 |
| 5.39 | 43.97 | 43.58 | 42.99 | 42.26 | 41.84 | 41.55 | 41.35 | 5.39 |
| 5.40 | 44.11 | 43.71 | 43.12 | 42.38 | 41.96 | 41.66 | 41.47 | 5.40 |
| 5.41 | 44.24 | 43.84 | 43.24 | 42.51 | 42.08 | 41.78 | 41.59 | 5.41 |
| 5.42 | 44.37 | 43.97 | 43.36 | 42.63 | 42.19 | 41.89 | 41.70 | 5.42 |
| 5.43 | 44.50 | 44.10 | 43.48 | 42.75 | 42.31 | 42.00 | 41.82 | 5.43 |
| 5.44 | 44.63 | 44.22 | 43.61 | 42.87 | 42.42 | 42.12 | 41.93 | 5.44 |
| 5.45 | 44.76 | 44.35 | 43.73 | 43.00 | 42.54 | 42.24 | 42.05 | 5.45 |
| 5.46 | 44.89 | 44.48 | 43.86 | 43.12 | 42.66 | 42.36 | 42.17 | 5.46 |
| 5.47 | 45.02 | 44.60 | 43.98 | 43.25 | 42.78 | 42.48 | 42.28 | 5.47 |
| 5.48 | 45.15 | 44.73 | 44.11 | 43.37 | 42.90 | 42.61 | 42.40 | 5.48 |
| 5.49 | 45.28 | 44.86 | 44.24 | 43.49 | 43.02 | 42.72 | 42.52 | 5.49 |
| 5.50 | 45.41 | 44.99 | 44.37 | 43.61 | 43.15 | 42.84 | 42.63 | 5.50 |
| 5.51 | 45.54 | 45.12 | 44.50 | 43.73 | 43.27 | 42.96 | 42.75 | 5.51 |
| 5.52 | 45.67 | 45.26 | 44.62 | 43.85 | 43.39 | 43.08 | 42.87 | 5.52 |
| 5.53 | 45.80 | 45.39 | 44.74 | 43.97 | 43.51 | 43.20 | 42.99 | 5.53 |
| 5.54 | 45.93 | 45.52 | 44.87 | 44.10 | 43.63 | 43.32 | 43.11 | 5.54 |
| 5.55 | 46.07 | 45.65 | 45.00 | 44.23 | 43.75 | 43.44 | 43.23 | 5.55 |
| 5.56 | 46.20 | 45.78 | 45.12 | 44.35 | 43.88 | 43.56 | 43.35 | 5.56 |
| 5.57 | 46.33 | 45.90 | 45.25 | 44.48 | 44.01 | 43.68 | 43.47 | 5.57 |
| 5.58 | 46.47 | 46.04 | 45.38 | 44.60 | 44.13 | 43.80 | 43.59 | 5.58 |
| 5.59 | 46.60 | 46.18 | 45.52 | 44.74 | 44.25 | 43.92 | 43.71 | 5.59 |
| 5.60 | 46.74 | 46.31 | 45.65 | 44.84 | 44.38 | 44.04 | 43.83 | 5.60 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=2$ Ft. $Q$ Cu. Ft. per Sec. | $p=3$ Ft. $Q$ Cu. Ft. per Sec. | $p=4$ Ft. $Q$ Cu. Ft. per Sec. | $p=5$ Ft. $Q$ Cu. Ft. per Sec. | $p=6$ Ft. $Q$ Cu. Ft. per Sec. | $p=7$ Ft. $Q$ Cu. Ft. per Sec. | $p=8$ Ft. $Q$ Cu. Ft. per Sec. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| 5.61 | 56.32 | 53.48 | 51.48 | 50.02 | 48.92 | 48.06 | 47.42 | 5.61 |
| 5.62 | 56.48 | 53.63 | 51.62 | 50.16 | 49.06 | 48.19 | 47.55 | 5.62 |
| 5.63 | 56.64 | 53.78 | 51.76 | 50.30 | 49.20 | 48.32 | 47.69 | 5.63 |
| 5.64 | 56.80 | 53.93 | 51.90 | 50.44 | 49.34 | 48.46 | 47.82 | 5.64 |
| 5.65 | 56.97 | 54.08 | 52.05 | 50.58 | 49.49 | 48.60 | 47.96 | 5.65 |
| 5.66 | 57.13 | 54.23 | 52.20 | 50.72 | 49.64 | 48.74 | 48.10 | 5.66 |
| 5.67 | 57.30 | 54.38 | 52.35 | 50.86 | 49.79 | 48.88 | 48.24 | 5.67 |
| 5.68 | 57.46 | 54.54 | 52.50 | 51.01 | 49.94 | 49.02 | 48.37 | 5.68 |
| 5.69 | 57.62 | 54.70 | 52.65 | 51.15 | 50.08 | 49.16 | 48.57 | 5.69 |
| 5.70 | 57.78 | 54.85 | 52.80 | 51.29 | 50.22 | 49.30 | 48.64 | 5.70 |
| 5.71 | 57.94 | 55.01 | 52.95 | 51.44 | 50.36 | 49.44 | 48.78 | 5.71 |
| 5.72 | 58.11 | 55.16 | 53.10 | 51.59 | 50.50 | 49.58 | 48.92 | 5.72 |
| 5.73 | 58.27 | 55.32 | 53.25 | 51.74 | 50.64 | 49.72 | 49.05 | 5.73 |
| 5.74 | 58.43 | 55.48 | 53.40 | 51.88 | 50.78 | 49.86 | 49.18 | 5.74 |
| 5.75 | 58.59 | 55.64 | 53.55 | 52.03 | 50.92 | 50.00 | 49.32 | 5.75 |
| 5.76 | 58.76 | 55.80 | 53.71 | 52.18 | 51.06 | 50.14 | 49.46 | 5.76 |
| 5.77 | 58.92 | 55.97 | 53.86 | 52.33 | 51.20 | 50.28 | 49.59 | 5.77 |
| 5.78 | 59.08 | 56.13 | 54.02 | 52.48 | 51.34 | 50.42 | 49.73 | 5.78 |
| 5.79 | 59.25 | 56.29 | 54.18 | 52.63 | 51.48 | 50.56 | 49.86 | 5.79 |
| 5.80 | 59.42 | 56.45 | 54.34 | 52.79 | 51.62 | 50.71 | 49.99 | 5.80 |
| 5.81 | 59.58 | 56.61 | 54.50 | 52.94 | 51.76 | 50.85 | 50.13 | 5.81 |
| 5.82 | 59.75 | 56.76 | 54.65 | 53.08 | 51.90 | 50.99 | 50.27 | 5.82 |
| 5.83 | 59.91 | 56.91 | 54.80 | 53.22 | 52.04 | 51.13 | 50.41 | 5.83 |
| 5.84 | 60.07 | 57.06 | 54.95 | 53.37 | 52.18 | 51.27 | 50.54 | 5.84 |
| 5.85 | 60.24 | 57.22 | 55.11 | 53.51 | 52.32 | 51.41 | 50.68 | 5.85 |
| 5.86 | 60.40 | 57.38 | 55.37 | 53.66 | 52.46 | 51.56 | 50.82 | 5.86 |
| 5.87 | 60.57 | 57.54 | 55.43 | 53.81 | 52.60 | 51.70 | 50.96 | 5.87 |
| 5.88 | 60.73 | 57.70 | 55.59 | 53.96 | 52.74 | 51.84 | 51.10 | 5.88 |
| 5.89 | 60.90 | 57.86 | 55.75 | 54.11 | 52.89 | 51.98 | 51.24 | 5.89 |
| 5.90 | 61.07 | 58.02 | 55.91 | 54.26 | 53.04 | 52.12 | 51.38 | 5.90 |
| 5.91 | 61.24 | 58.19 | 56.06 | 54.41 | 53.19 | 52.26 | 51.52 | 5.91 |
| 5.92 | 61.41 | 58.35 | 56.22 | 54.56 | 53.34 | 52.40 | 51.66 | 5.92 |
| 5.93 | 61.58 | 58.51 | 56.37 | 54.71 | 53.49 | 52.54 | 51.80 | 5.93 |
| 5.94 | 61.75 | 58.67 | 56.52 | 54.86 | 53.63 | 52.69 | 51.94 | 5.94 |
| 5.95 | 61.92 | 58.83 | 56.68 | 55.01 | 53.78 | 52.83 | 52.08 | 5.95 |
| 5.96 | 62.09 | 58.99 | 56.83 | 55.16 | 53.93 | 52.98 | 52.22 | 5.96 |
| 5.97 | 62.26 | 59.15 | 56.98 | 55.32 | 54.08 | 53.12 | 52.36 | 5.97 |
| 5.98 | 62.43 | 59.32 | 57.13 | 55.47 | 54.23 | 53.26 | 52.50 | 5.98 |
| 5.99 | 62.60 | 59.48 | 57.28 | 55.62 | 54.38 | 53.40 | 52.64 | 5.99 |
| 6.00 | 62.77 | 59.65 | 57.43 | 55.78 | 54.53 | 53.55 | 52.78 | 6.00 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

| $h$ in Feet. | $p=9$ Ft. | $p=10$ Ft. | $p=12$ Ft. | $p=16$ Ft. | $p=20$ Ft. | $p=25$ Ft. | $p=30$ Ft. | $h$ in Feet. |
|---|---|---|---|---|---|---|---|---|
| | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | $Q$ Cu. Ft. per Sec. | |
| 5.61 | 46.87 | 46.45 | 45.78 | 44.97 | 44.49 | 44.16 | 43.94 | 5.61 |
| 5.62 | 47.00 | 46.58 | 45.90 | 45.09 | 44.61 | 44.27 | 44.05 | 5.62 |
| 5.63 | 47.13 | 46.71 | 46.03 | 45.22 | 44.74 | 44.39 | 44.16 | 5.63 |
| 5.64 | 47.26 | 46.84 | 46.15 | 45.35 | 44.86 | 44.51 | 44.28 | 5.64 |
| 5.65 | 47.39 | 46.97 | 46.28 | 45.48 | 44.98 | 44.63 | 44.40 | 5.65 |
| 5.66 | 47.52 | 47.11 | 46.41 | 45.60 | 45.11 | 44.75 | 44.52 | 5.66 |
| 5.67 | 47.65 | 47.24 | 46.53 | 45.73 | 45.23 | 44.87 | 44.64 | 5.67 |
| 5.68 | 47.79 | 47.37 | 46.65 | 45.85 | 45.35 | 44.99 | 44.76 | 5.68 |
| 5.69 | 47.92 | 47.50 | 46.77 | 45.97 | 45.48 | 45.11 | 44.88 | 5.69 |
| 5.70 | 48.05 | 47.63 | 46.90 | 46.09 | 45.60 | 45.23 | 45.00 | 5.70 |
| 5.71 | 48.19 | 47.76 | 47.02 | 46.22 | 45.73 | 45.35 | 45.12 | 5.71 |
| 5.72 | 48.32 | 47.89 | 47.16 | 46.34 | 45.85 | 45.47 | 45.24 | 5.72 |
| 5.73 | 48.45 | 48.02 | 47.29 | 46.47 | 45.97 | 45.59 | 45.36 | 5.73 |
| 5.74 | 48.58 | 48.15 | 47.42 | 46 60 | 46.09 | 45.71 | 45.48 | 5.74 |
| 5.75 | 48.71 | 48.28 | 47.55 | 46.72 | 46.21 | 45.83 | 45.60 | 5.75 |
| 5.76 | 48.85 | 48.42 | 47.69 | 46.84 | 46.33 | 45.95 | 45.72 | 5.76 |
| 5.77 | 48.99 | 48.55 | 47.82 | 46.97 | 46.46 | 46.07 | 45.84 | 5.77 |
| 5.78 | 49.13 | 48.68 | 47.95 | 47.09 | 46.58 | 46.19 | 45.96 | 5.78 |
| 5.79 | 49.27 | 48.81 | 48.08 | 47.21 | 46.70 | 46.33 | 46.09 | 5.79 |
| 5.80 | 49.41 | 48.94 | 48.22 | 47.33 | 46.83 | 46.45 | 46.22 | 5.80 |
| 5.81 | 49.54 | 49.07 | 48.35 | 47.46 | 46.95 | 46.57 | 46.34 | 5.81 |
| 5.82 | 49.68 | 49.21 | 48.48 | 47.59 | 47.07 | 46.69 | 46.46 | 5.82 |
| 5.83 | 49.81 | 49.35 | 48.61 | 47.72 | 47.19 | 46.81 | 46.58 | 5.83 |
| 5.84 | 49.95 | 49.48 | 48.74 | 47.85 | 47.31 | 46.93 | 46.70 | 5.84 |
| 5.85 | 50.08 | 49.61 | 48.87 | 47.97 | 47.43 | 47.05 | 46.82 | 5.85 |
| 5.86 | 50.22 | 49.74 | 49.00 | 48.10 | 47.55 | 47.17 | 46.94 | 5.86 |
| 5.87 | 50.36 | 49.87 | 49.13 | 48.22 | 47.68 | 47.30 | 47.06 | 5.87 |
| 5.88 | 50.50 | 50.00 | 49.26 | 48.34 | 47.80 | 47.42 | 47.18 | 5.88 |
| 5.89 | 50.64 | 50.14 | 49.39 | 48.47 | 47.93 | 47.54 | 47.30 | 5.89 |
| 5.90 | 50.77 | 50.28 | 49.52 | 48.60 | 48.06 | 47.67 | 47.42 | 5.90 |
| 5.91 | 50.91 | 50.41 | 49.66 | 48.73 | 48.19 | 47.80 | 47.54 | 5.91 |
| 5.92 | 51.05 | 50.55 | 49.79 | 48.86 | 48.31 | 47.92 | 47.67 | 5.92 |
| 5.93 | 51.19 | 50.68 | 49.92 | 48.99 | 48.43 | 48.04 | 47.79 | 5.93 |
| 5.94 | 51.33 | 50.82 | 50.05 | 49.12 | 48.56 | 48.17 | 47.92 | 5.94 |
| 5.95 | 51.47 | 50.96 | 50.19 | 49.25 | 48.65 | 48.29 | 48.04 | 5.95 |
| 5.96 | 51.61 | 51.10 | 50.33 | 49.38 | 48.81 | 48.42 | 48.17 | 5.96 |
| 5.97 | 51.75 | 51.24 | 50.46 | 49.51 | 48.94 | 48.55 | 48.39 | 5.97 |
| 5.98 | 51.88 | 51.38 | 50.59 | 49.64 | 49.07 | 48.67 | 48.42 | 5.98 |
| 5.99 | 52.02 | 51.51 | 50.72 | 49.77 | 49.20 | 48.79 | 48.55 | 5.99 |
| 6.00 | 52.15 | 51.64 | 50.86 | 49.90 | 49.34 | 48.92 | 48.67 | 6.00 |

## DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

### COMPUTED BY BAZIN'S FORMULA.

| $h$ | $p=10'$ | $p=20'$ | $p=30'$ |
|---|---|---|---|
| 6 | 51.67 | 49.36 | 48.69 |
| 7 | 66.04 | 62.64 | 61.59 |
| 8 | 81.78 | 77.08 | 75.56 |
| 9 | 98.85 | 92.65 | 90.57 |
| 10 | 117.16 | 109.32 | 106.57 |
| 11 | ...... | 127.06 | 123.54 |
| 12 | ...... | 145.85 | 141.46 |
| 13 | ...... | 165.65 | 160.30 |
| 14 | ...... | 186.45 | 180.04 |
| 15 | ...... | 208.23 | 200.68 |
| 16 | ...... | ...... | 222.18 |
| 17 | ...... | ...... | 244.55 |
| 18 | ...... | ...... | 267.76 |
| 19 | ...... | ...... | 291.81 |
| 20 | ...... | ...... | 316.66 |

## LOW HEADS.

For heads below 0.2 foot the Bazin Formula gives discharges somewhat in excess of the experimental results of Fteley and Stearns, and in practice accurate weir measurement at low heads becomes extremely difficult on account of the increased relative importance of errors of observation, and of changes in the character of the flow if the edge of the weir has a measurable thickness. It may also be expected that the temperature of the water will exercise considerable influence. For these low heads the formula deduced by Fteley and Stearns for their small weir, $Q=3.33LH^{3/2}+0.0065L$, gives results varying from the experiments by from 4 to 6 per cent for heads from 0.2 to 0.07 foot, the lowest observed. The actual results were usually greater than those given by the formula. For a head of 0.1 foot this formula gives a discharge of 0.11 cu. ft. per second, as compared with 0.13 cu. ft. by Bazin. A value of 0.115 cu. ft. seems quite nearly correct for this head.

## END CONTRACTIONS.

For weirs having end contractions the formula of Mr. Francis, modified as he proposed by subtracting the quantity $0.1nH$ from the value of $L$, making the formula $Q=3.33(L-0.1nH)H^{3/2}$, is the one generally recognized. In this modification $n$ is the number of end contractions, or the proportion of a complete contraction. Recent experiments indicate that the effect of end contractions is not to be provided for by so simple a formula, and until more data are available such weirs should be avoided so far as circumstances will permit.

## VERY HIGH WEIRS.

When the weir is of such dimensions in proportion to the channel of approach that the velocity of the approaching water may become zero, the formula of Bazin reduces to $Q=\left(0.405+\dfrac{0.00984}{h}\right)Lh\sqrt{2gh}$, which corresponds to $p=$ infinity, and the table on page 108 gives the value of the several factors, and the discharge under this condition for $L=1$ foot. In this and the preceding table $g$ has been taken as 32.173 feet, that being its value for latitude 40° and an elevation above sea-level of 500 feet.

## VALUES OF FACTORS IN BAZIN'S FORMULA AND DISCHARGE OVER WEIR OF INFINITE HEIGHT.

| Head = $h$ in Feet. | $\sqrt{2gh}$ | $h\sqrt{2gh}$ | $\left(0.405+\frac{0.00984}{h}\right)$ | Discharge $Q$ in Cu. Ft. per Sec. for $L=1$ Foot. |
|---|---|---|---|---|
| 0.1 | 2.537 | 0.254 | 0.503 | 0.13 |
| 0.2 | 3.587 | 0.717 | 0.454 | 0.33 |
| 0.3 | 4.394 | 1.318 | 0.438 | 0.58 |
| 0.4 | 5.073 | 2.029 | 0.430 | 0.87 |
| 0.5 | 5.672 | 2.836 | 0.425 | 1.20 |
| 0.6 | 6.213 | 3.728 | 0.421 | 1.57 |
| 0.7 | 6.711 | 4.698 | 0.419 | 1.97 |
| 0.8 | 7.175 | 5.740 | 0.417 | 2.40 |
| 0.9 | 7.610 | 6.849 | 0.416 | 2.85 |
| 1.0 | 8.021 | 8.021 | 0.415 | 3.33 |
| 1.2 | 8.787 | 10.544 | 0.413 | 4.36 |
| 1.4 | 9.491 | 13.287 | 0.412 | 5.48 |
| 1.5 | 9.824 | 14.736 | 0.412 | 6.07 |
| 1.6 | 10.147 | 16.234 | 0.411 | 6.68 |
| 1.8 | 10.762 | 19.361 | 0.410 | 7.95 |
| 2.0 | 11.344 | 22.688 | 0.410 | 9.30 |
| 2.2 | 11.898 | 26.178 | 0.409 | 10.72 |
| 2.4 | 12.427 | 29.825 | 0.409 | 12.20 |
| 2.5 | 12.683 | 31.707 | 0.409 | 12.97 |
| 2.6 | 12.934 | 33.631 | 0.409 | 13.75 |
| 2.8 | 13.423 | 37.585 | 0.409 | 15.35 |
| 3.0 | 13.894 | 41.682 | 0.408 | 17.02 |
| 3.2 | 14.349 | 45.915 | 0.408 | 18.74 |
| 3.4 | 14.791 | 50.290 | 0.408 | 20.51 |
| 3.5 | 15.008 | 52.523 | 0.408 | 21.42 |
| 3.6 | 15.219 | 54.785 | 0.408 | 22.34 |
| 3.8 | 15.637 | 59.420 | 0.408 | 24.22 |
| 4.0 | 16.043 | 64.170 | 0.407 | 26.15 |
| 4.2 | 16.439 | 69.045 | 0.407 | 28.13 |
| 4.4 | 16.826 | 74.030 | 0.407 | 30.15 |
| 4.6 | 17.204 | 79.140 | 0.407 | 32.22 |
| 4.8 | 17.574 | 84.360 | 0.407 | 34.34 |
| 5.0 | 17.936 | 89.625 | 0.407 | 36.48 |
| 5.2 | 18.292 | 95.120 | 0.407 | 38.70 |
| 5.4 | 18.640 | 100.656 | 0.407 | 40.95 |
| 5.6 | 18.983 | 106.305 | 0.407 | 43.24 |
| 5.8 | 19.318 | 112.044 | 0.407 | 45.56 |
| 6.0 | 19.648 | 117.888 | 0.407 | 47.94 |

## FLAT-CREST AND OTHER WEIRS.

THE formulas for the discharge of vertical sharp-edged weirs cease to be applicable when the crest is widened or the up-stream face inclined, and in order to determine what modifications should be made in the computed results, experiments have been made upon some twenty-five models of different forms, with $L=16$ feet and $p$ as great as 11.25 feet, using heads up to and in some cases a little above 4 feet.

In the case of flat-crest weirs it has been found that for a range of head between 1.6 and 4.0 times the breadth of the crest the discharge depends upon whether the head within that range is reached by the water lowering from a head above it or rising from a lower one. In the latter case owing to the adhesion of the overflowing water to the crest of the weir the discharge is increased, in some cases as much as 13 per cent. On a falling head the sheet will apparently jump clear of the crest so long as the head is above 1.6 times the breadth of the crest, and the discharge will correspond to that of a sharp-edged weir, but when the stream is rising the sheet does not break free from the crest until the head is nearly four times the breadth of the crest, and under these conditions for all heads above 1.6 times the breadth, the discharge will be greater than that of a sharp-edged weir until the sheet breaks away. This variable condition is indicated in the table for "Rectangular Flat-Topped Weirs" by the columns designated, "Falling Head" and "Rising Head."

From these experiments the factors by which to multiply the computed discharge for a sharp-edged weir of the same $L$ and $p$, to give the actual discharge over each form of crest, have been deduced for the heads given in the following tables, wherein the first column gives the head and the columns headed II the multipliers. To use the tables, the discharge for the weir of given form should be first computed as for a vertical sharp-edged weir of the same height and length, using any of the above formulas, or the tables on pages 76 to 105 and resulting $Q$s should then be multiplied by the factor in the proper column under II, when the accuracy of the result may be expected to correspond to that of the first computation. So long as the top of the weir is flat and the up-stream face vertical, it appears that the factors given should be applicable to any height of weir, but if the up-stream face or any part of the profile up-stream, from the highest point of the weir, is inclined, the factor will change with the height of the weir, as is shown by the table for triangular weirs.

On all the models having vertical down-stream faces, including model P, air was admitted to the space underneath the sheet. On models D and E experiments were made with the space underneath

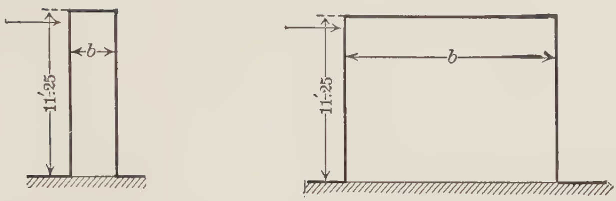
the sheet unaerated, so that a partial vacuum existed there, which is shown to increase the discharge about 5 per cent at the high heads. For the weirs with inclined down-stream faces, models F to O inclusive, no air was admitted under the sheet. A comparison of the results upon models G and H shows the effect of rounding the up-stream corner of this weir to be an increase in discharge of about 4 per cent at the high heads.

## SUBMERGED WEIRS.

With crests of the forms *L* and *N*, pages 113 and 115, experiment shows that until the submergence amounts to 30 per cent of the head, the reduction of discharge is less than 10 per cent. In fact so long as the overfalling water plunges beneath that in the downstream channel the discharge appears to be diminished by not more than the above amount.

# WEIR DISCHARGE.

## RECTANGULAR FLAT-TOPPED WEIRS.

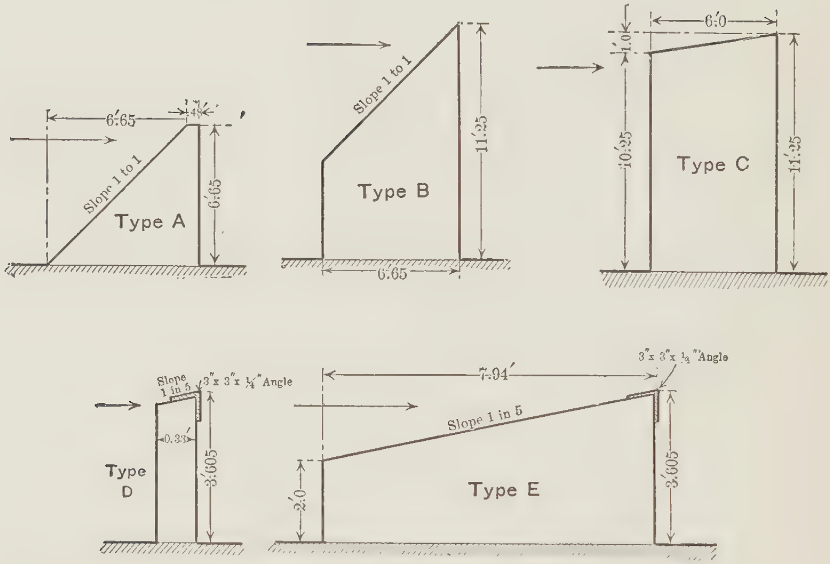



| I. Head in Feet, *h*. | II. Multipliers of Discharge over Sharp-edged Vertical Weir of same *L* and *p*. | | | | | |
|---|---|---|---|---|---|---|
| | *b* = 0.48 Ft. | | *b* = 0.93 Ft. | | *b* = 1.65 Ft. | |
| | Falling Head. | Rising Head. | Falling Head. | Rising Head. | Falling Head. | Rising Head. |
| 0.5 | 0.88 | 0.90 | 0.815 | 0.815 | 0.81 | 0.81 |
| 1.0 | 1.00 | 1.07 | 0.90 | 0.95 | 0.83 | 0.83 |
| 1.5 | 1.00 | 1.12 | 0.995 | 1.03 | 0.885 | 0.885 |
| 2.0 | 1.00 | 1.00 | 1.00 | 1.06 | 0.95 | 0.95 |
| 2.5 | 1.00 | 1.00 | 1.00 | 1.10 | 0.99 | 1.00 |
| 3.0 | 1.00 | 1.00 | 1.00 | 1.13 | 1.00 | 1.03 |
| 3.5 | 1.00 | 1.00 | 1.00 | 1.05 | 1.00 | 1.07 |
| 4.0 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.10 |

| I. Head in Feet, *h*. | II. Multipliers of Discharge over Sharp-edged Vertical Weir of Same *L* and *p*. | | | | |
|---|---|---|---|---|---|
| | *b* = 3.17 Ft. Rising and Falling Heads. | *b* = 5.84 Ft. | *b* = 8.98 Ft. | *b* = 12.24 Ft. | *b* = 16.30 Ft. |
| 0.5 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 |
| 1.0 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 |
| 1.5 | 0.80 | 0.80 | 0.795 | 0.795 | 0.79 |
| 2.0 | 0.82 | 0.80 | 0.79 | 0.79 | 0.79 |
| 2.5 | 0.85 | 0.80 | 0.79 | 0.79 | 0.79 |
| 3.0 | 0.87 | 0.80 | 0.79 | 0.79 | 0.79 |
| 3.5 | 0.905 | 0.81 | 0.79 | 0.79 | 0.79 |
| 4.0 | 0.94 | 0.82 | 0.79 | 0.79 | 0.79 |

# WEIR DISCHARGE.

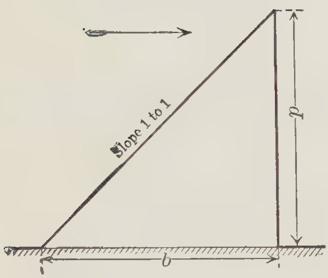
## TRAPEZOIDAL WEIRS.




| I. Head in Feet, *h*. | II. Multipliers of Discharge over Sharp-edged Vertical Weir of Same $L$ and $p$. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Type A. | Type B. | Type C. | Type D. | D with Vacuum. | Type E. | E with Vacuum. |
| 0.5 | 0.968 | 1.060 | 1.043 | 1.069 | 1.088 | 1.069 | 1.069 |
| 1.0 | 1.071 | 1.079 | 1.040 | 1.079 | 1.106 | 1.079 | 1.079 |
| 1.5 | 1.077 | 1.091 | 1.037 | 1.084 | 1.117 | 1.088 | 1.092 |
| 2.0 | 1.081 | 1.096 | 1.027 | 1.057 | 1.092 | 1.063 | 1.083 |
| 2.5 | 1.077 | 1.093 | 1.015 | 1.041 | 1.079 | 1.049 | 1.081 |
| 3.0 | 1.074 | 1.090 | 1.005 | 1.028 | 1.068 | 1.039 | 1.080 |
| 3.5 | 1.071 | 1.087 | 0.996 | 1.018 | 1.059 | 1.029 | 1.079 |
| 4.0 | 1.069 | 1.085 | 0.989 | 1.009 | 1.051 | 1.021 | 1.078 |

# WEIR DISCHARGE.

## TRIANGULAR WEIRS.



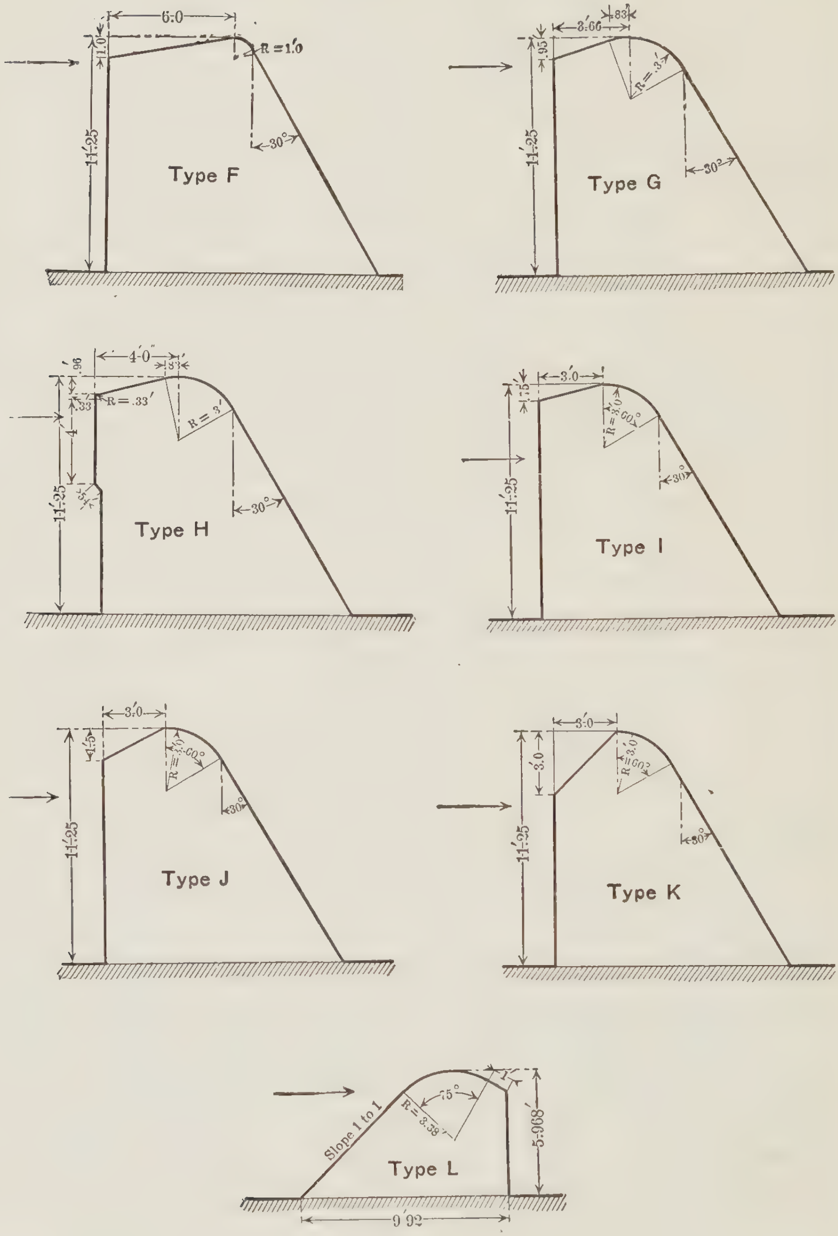

| I. Head in Feet, $h$. | II. Multipliers. | |
|---|---|---|
| | $b=p=$ 6.65 Ft. | $b=p=$ 11.25 Ft. |
| 0.5 | 1.060 | 1.060 |
| 1.0 | 1.079 | 1.079 |
| 1.5 | 1.091 | 1.092 |
| 2.0 | 1.086 | 1.097 |
| 2.5 | 1.076 | 1.096 |
| 3.0 | 1.067 | 1.095 |
| 3.5 | 1.060 | 1.094 |
| 4.0 | 1.054 | 1.093 |

## COMPOUND WEIRS.

See page 114.

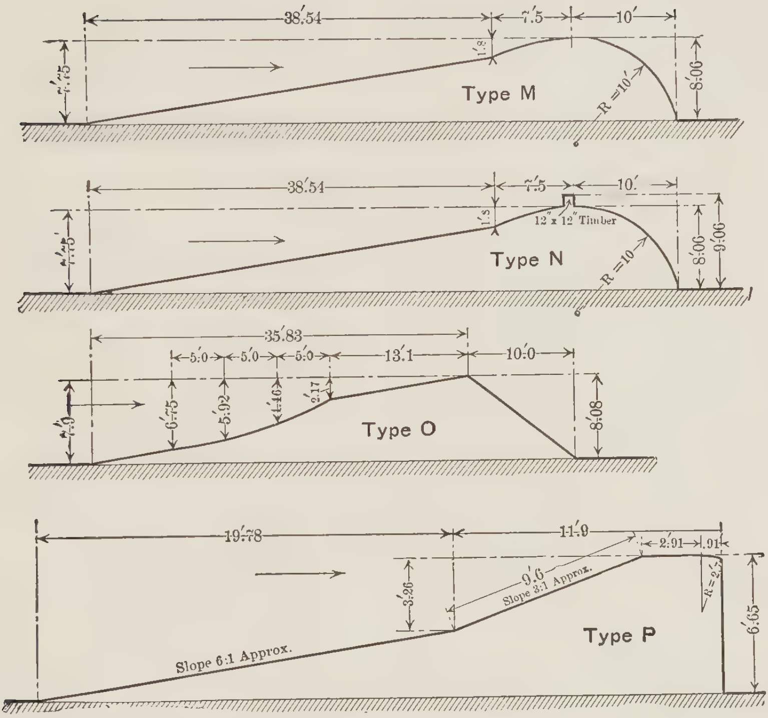
| I. Head in Feet, $h$. | II. Multipliers. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Type F. | Type G. | Type H. | Type I. | Type J. | Type K. | Type L. |
| 0.5 | 0.964 | 0.932 | 0.934 | 0.968 | 0.971 | 0.971 | 0.971 |
| 1.0 | 1.026 | 0.982 | 1.000 | 1.008 | 1.040 | 1.040 | 0.983 |
| 1.5 | 1.064 | 1.015 | 1.040 | 1.030 | 1.083 | 1.092 | 1.022 |
| 2.0 | 1.066 | 1.031 | 1.061 | 1.034 | 1.113 | 1.126 | 1.040 |
| 2.5 | 1.025 | 1.038 | 1.073 | 1.038 | 1.118 | 1.146 | 1.057 |
| 3.0 | 0.992 | 1.044 | 1.082 | 1.042 | 1.120 | 1.163 | 1.072 |
| 3.5 | 0.966 | 1.049 | 1.090 | 1.046 | 1.122 | 1.177 | 1.085 |
| 4.0 | 0.944 | 1.053 | 1.097 | 1.050 | 1.125 | 1.190 | 1.097 |

## COMPOUND WEIRS.



# WEIR DISCHARGE.

## COMPLEX WEIRS.




| I.<br>Head in Feet, *h*. | II.<br>Multipliers. | | | |
|---|---|---|---|---|
| | Type M. | Type N. | Type O. | Type P. |
| 0.5 | 0.964 | 0.897 | 1.095 | 0.920 |
| 1.0 | 0.965 | 0.946 | 1.088 | 0.915 |
| 1.5 | 0.963 | 0.999 | 1.084 | 0.914 |
| 2.0 | 0.949 | 1.025 | 1.069 | 0.935 |
| 2.5 | 0.933 | 1.039 | 1.051 | 0.950 |
| 3.0 | 0.920 | 1.052 | 1.035 | 0.962 |
| 3.5 | 0.911 | 1.063 | 1.024 | 0.972 |
| 4.0 | 0.903 | 1.072 | 1.014 | 0.982 |